USE OF SPACE AND ACTIVITY RHYTHMS OF SPOTTED-NECKED OTTERS IN THE NATAL DRAKENSBERG

by

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PREFACE

This research was carried out while I was a student in the Department of Zoology and Entomology, University of Natal, Pietermaritzburg, from May 1994 to September 1995. The project was supervised by Professor M.R. Perrin and co supervised by Dr D.T. Rowe Rowe.

This research is my original work and has not been submitted in any form to another university.

Ilaria d'Inzillo Carranza

To Colombo, Umfula, Luma, Baleka, Umtwana,

Savuka and Shaka

ABSTRACT

The study was carried out in Kamberg Nature Reserve (Natal Drakensberg) from June 1994 to August 1995. Seven spotted-necked otters were fitted with an intraperitoneal radio-implant; radio-tracking was performed by both temporally independent locations and 24h continuous tracking sessions.

When active, otters were always found in aquatic habitats, mainly dams, the river or oxbow lakes. Dense vegetation cover, as trees, reeds, and tall grass were preferred while resting. Otters were active both during the day and during the night, with peaks of activity at twilight. The amount of time spent in consecutive activity varied seasonally together with the main prey items exploited.

Average home range area was 11,3 km², including a stretch of river with an average length of 14,8 km. No intersexual nor intrasexual territoriality was detected. Intraspecific relationships varied with the dispersion and availability of food resources.

ACKNOWLEDGEMENTS

This research would not have been possible without the collaboration of various people. Professor M.R. Perrin and Dr D.T. Rowe-Rowe, respectively supervisor and co supervisor of the research, assisted and advised me constantly throughout the different phases of the project, and showed great patience in correcting the drafts of a non-english speaking student. Funds were made available from the University of Natal, F.R.D. Programme (Prof M.R. Perrin), Natal Parks Board, and L.A.U.B. (Dr Jürgen Ott). Accommodation in the field was provided by Natal Parks Board.

Ian Maloni, Officer in charge in Kamberg Nature Reserve, and his wife Sue, kindly assisted me during my stay in Kamberg Nature Reserve. Rob Karssing, manager of the trout hatchery in Kamberg, was always willing to help in the field work and gave important imput into the project with stimulating conversations.

Traps were supplied by Peter Moller, Thomas Teron, and Giorgio Verolini, farmers in the Nottingham Road and Mooi River areas. Peter Moller and his wife Joan at Riverside Farm assisted me constantly during the field work, as well as Giorgio Verolini and his wife Milvia, who were always helpful and encouraging.

Peter Dommett offerred free veterinary services to the project and performed the surgical operations necessary for the installation of the radio-implants. Mr Ian Linn (University of Exeter, U.K.) provided the computer package used in the calculation of animal home-ranges and gave essential suggestions concerning the utilization of that computer programme. Field life often implies punched tyres and broken traps; I am thankful to all of the staff of Kamberg Nature Reserve, particularly Albert, for always being willing to give a hand.

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Jaishree Raman often substituted for the use of a dictionary and corrected drafts during the writing up period.

My parents financed my first year in South Africa and supported me throughout. This project was planned and carried out in total collaboration with Caterina Carugati, with whom I shared all the difficulties and satisfactions of sixteen months of 'otter tracking', an an experience that will never be forgotten.

CHAPTER 1 INTRODUCTION

The Eurasian otter (*Lutra lutra*), spotted-necked otter (*Lutra maculicollis*), Cape clawless otter (*Aonyx capensis*), and the Congo clawless otter (*Aonyx congica*) are the four otter species occurring in Africa. In most of the African continent, the presence of otters is threatened by the increasing human population. Habitat loss and alteration, agricultural activity, overgrazing, erosion, and river pollution, are all direct consequences of human activity, which are the main causes affecting otters (Rowe Rowe, 1990).Spotted necked otters occur throughout most of sub-Saharan Africa, coexisting with either the Cape clawless otter or the Congo clawless otter. In 25 of the 33 African coutries in which they occur, spotted-necked otters are considered rare to very rare (Rowe-Rowe, 1990). The status of the spotted-necked otter is unknown in most of these countries, and in Burundi, Ghana, Lesotho and Togo it is believed to be extirpated. The legal status of "fully protected" has only been legislated only in Kenya, Botswana and Malawi, while in most African coutries they are protected only in national parks and reserves. In Angola, Burundi, Cameroon and Mali there is no legislation concerning this species. In South Africa their distribution is limited to the eastern half of the country, occurring in the eastern Transvaal, Orange Free State, Natal and Eastern Cape (Skinner & Smithers, 1990). They are considered to be rare and declining (Rowe-Rowe, 1990), but the legal status of "protected" is limited to national parks and game or nature reserves, while outside protected areas they are umprotected, but live animals or parts of them (e.g. skins) may not be sold.

In the Natal Drakensberg spotted necked otters are fairly common. Occasionally exploiting trout hatcheries and stocked dams, they are considered pests by some farmers and are therefore actively persecuted. Skin and other parts of their body are occasionally used in traditional medicine (Cunningham & Zondi, 1991; Rowe-Rowe, 1992a).

Owing to the status described previously, and in order to preserve the species, a large scale conservation plan is needed. A conservation plan presupposes detailed knowledge of a species ecology and requires information about the factors determining the presence and abundance of individuals.

Literature concerning spotted-necked otter ecology is limited mainly to the diet (Lejeune, 1990; Kruuk & Goudswaard, 1990; Mortimer, 1963; Procter, 1963; Rowe-Rowe, 1977a; Rowe-Rowe 1977b; Carugati, in prep.). Some information regarding habitat use is given by Lejeune (1989), Lejeune & Frank (1990), Rowe-Rowe (1975; 1978; 1992a), Procter (1963) and Mortimer (1963). Data concerning activity rhythms, space use and intraspecific relationships were mainly collected in central African lakes (Lejeune, 1989; Lejeune & Frank, 1990; Kruuk & Goudswaard, 1990; Procter, 1963), while the only information available on riverine habitat use are a few observations reported by Rowe-Rowe (1978; 1992a; 1992b). The present research investigates the main aspects of the temporal and spatial ecology of this species in order to contribute to a larger scale conservation plan, particularly:

- habitat use and habitat selection
- activity rhythms
- spacing patterns
- intraspecific relationships

The study was carried out in Kamberg Nature Reserve in the Natal Drakensberg, where various environment management practices are employed. The reserve includes a trout hatchery and dams regularly stocked with trout (Hatchery area), and a wild pristine area (Stillerust area). The two areas are separated by a rural village and farmland, both situated along the same river as the protected areas. It was therefore possible to compare the presence of the species in different types of anthropogenic environments and in a wilderness area. Flexibility in territorial and social behaviour, and variations in spacing patterns in relation to food resource dispersion and availability are found in many species of mammals (Bacon, Ball & Blackwell, 1991; Balharry, 1993; Mills, 1989). In the Hatchery area food resources were concentrated and were not subjected to seasonal variation in abundance, whereas in the Stillerust area, food resources were naturally more dispersed and their abundance varied seasonally. In order to investigate the intraspecific relationships of spotted-necked otters in relation to food resource availability, the following hypotheses are tested:

1) spacing patterns do not vary with food resource availability

2) intraspecific relationships do not vary with food resource availability.

CHAPTER 2 STUDY AREA

2.1 GEOGRAPHICAL LOCATION AND GENERAL DESCRIPTION

The study was carried out in Kamberg Nature Reserve (29°.21'S 29°.27'S; 29°.38'E 29°.48'E), situated in the central Drakensberg, which forms part of the 240000 ha Natal Drakensberg Park. The reserve encloses 2232 ha and includes about 12 km of the Mooi River and several small tributaries and streams. The two protected stretches of the Mooi River are separated by unprotected areas including a rural village and farmland. The altitude range extends from 1640 m (Stillerust) to 2243 m (Gladstone's Nose).

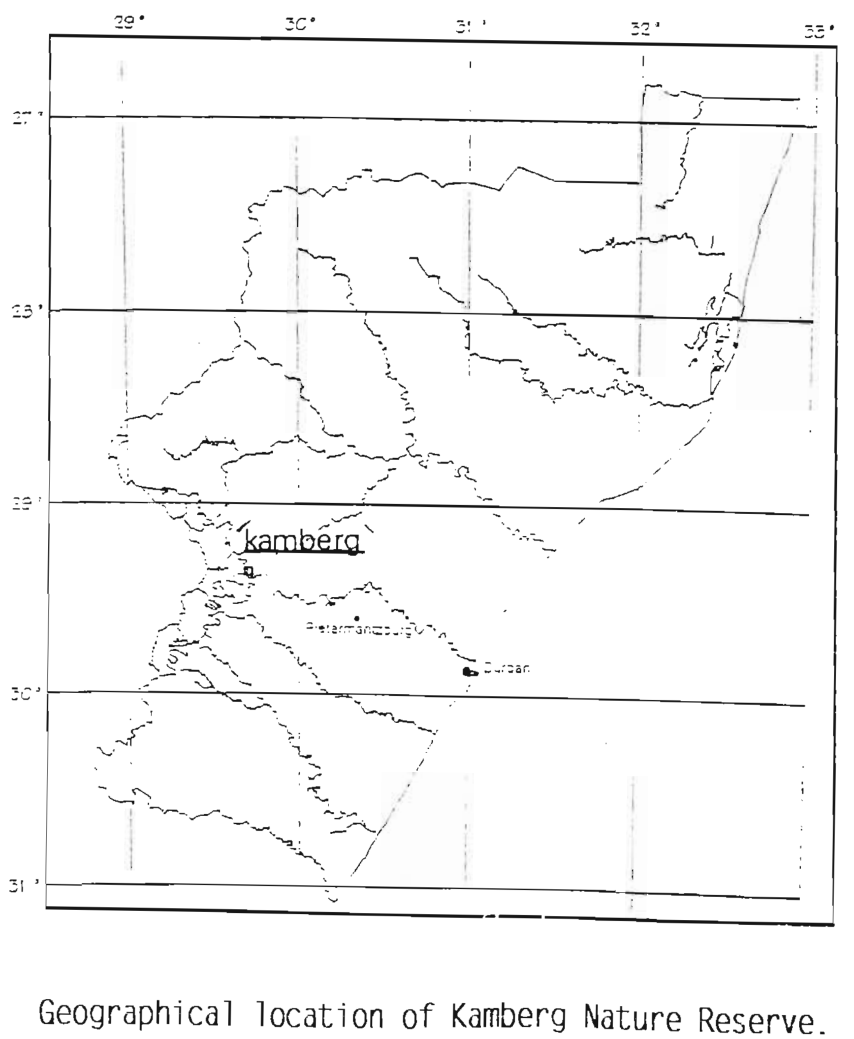

Figure 2.1 Geographical location of Kamberg Nature Reserve.

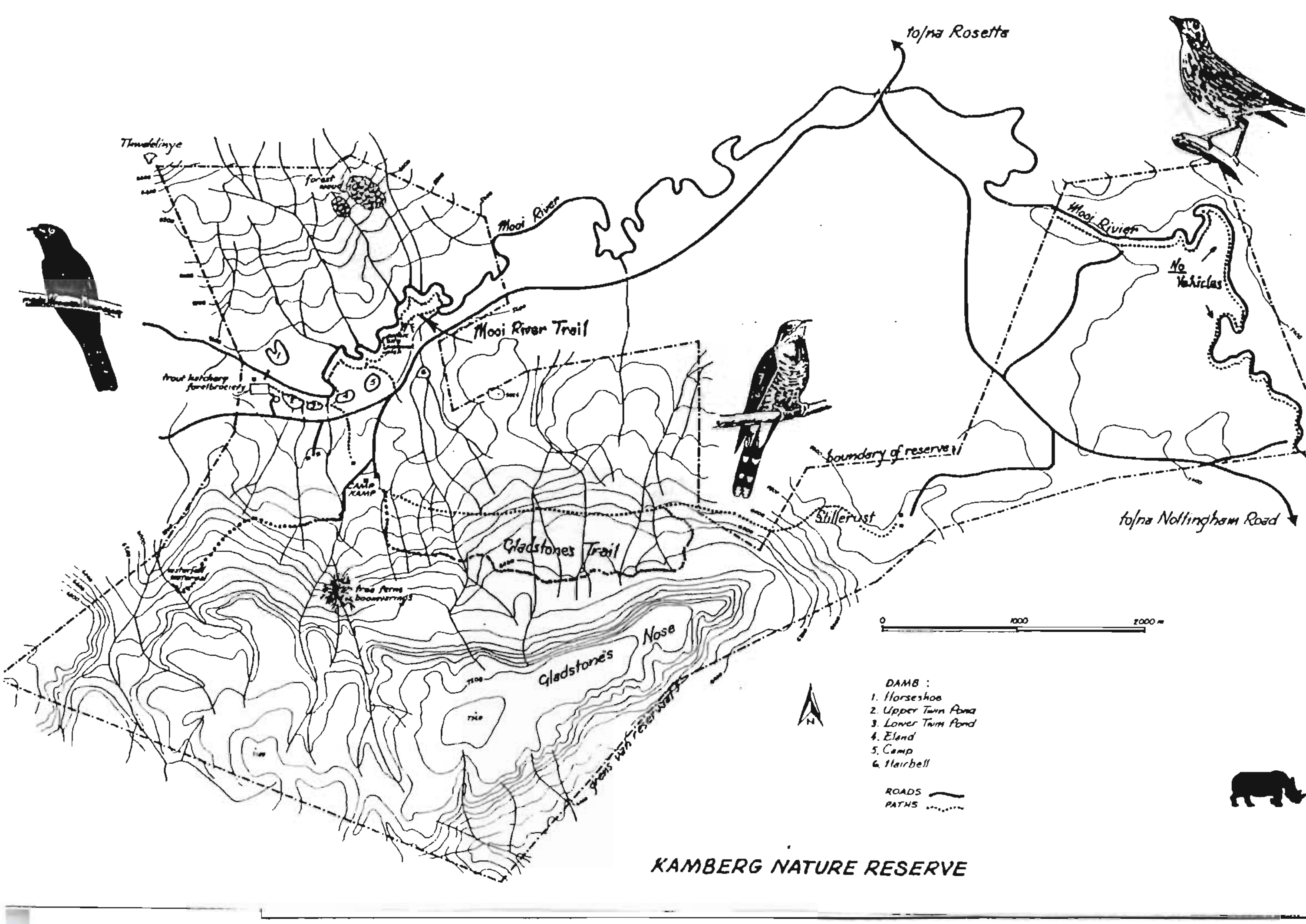

Figure 2.2 Map of Kamberg Nature Reserve.

2.2 CLIMATE

Kamberg Nature Reserve is in the Highland bioclimatic region (Phillips, 1973). Rainfall occurs mainly between October and March and approximates 1000 mm per annum. Mean daily maximum and minimum temperature are 25°C and 13°C in midsummer (January), and 17°C and 1°C in midwinter (June). Between April and September, temperatures often fall below 0°C. Mean monthly temperatures and rainfall are reported (Table 2.1) for the period of the study (Natal Parks Board).

Table 2.1 Mean monthly temperatures (°C) and rainfall (mm) in Kamberg Nature Reserve from June 1994 to August 1995 (Natal Parks Board).

	jul94	aug94	sept94	oct94	nov94	dec94	jan95	feb95	mar95	apr95	may95	jun95	jul95	aug95
minimum	1,7	4,5	9,2	8,4	11,2	12,7	13,9	14,8	12,3	8,6	6,2	3,0	3,3	5,4
maximum	15,3	17,2	21,5	17,3	22,3	22,3	22,9	25,4	20,8	17,8	17,8	15,7	17,1	20,1
rainfall	34,1	15,0	4,1	98,9	28,5	123,6	256,4	48,8	223,9	119,7	9,7	28,1	0	0

2.3 GEOLOGY, GEOMORPHOLOGY AND SOILS

The geology of the Natal Drakensberg is characterized by horizontal rock strata constituted mainly by sedimentary and igneous deposits. Layers of sandstone deposited by water and wind were covered by molten lava which cooled to form basalt. Most of the basalt today has been eroded away with the exception of the highland plateau of Lesotho. The present landscape is therefore characterized by the rock layers that become exposed as a consequence of erosion. Being continually under changing conditions, soils show a very heterogenous pattern. In general, high iron content and acidity are characteristics of the soils of the Natal Drakensberg (Irwin & Irwin, 1992).

2.4 VEGETATION

The major vegetation type occurring in the Natal Drakensberg is grassland (almost 90%). The other plant communities occurring are forest, scrub, fynbos, *Protea* savanna, montane and sub-alpine grassland, alpine grassland and *Erica-helichrysum* heath.

In Kamberg Nature Reserve all the communities mentioned above are represented except for the fynbos.The riverine habitat consists of scrub (*Leucosidea sericea, Buddleia salviifolia*), wetland grass (*Mexmuellera sp.*), and open grassland (*Themenda trianda, Tristachya leucothrix*). Alien plants such as willow trees (*Salix babilonica*) and wattle trees (*Acacia mearnsii*) also occasionally occur on the river banks (Killick, 1990). Cultivation and pastures characterize the river banks in Tendele village, where arboreal cover was very poor, and mainly provided by wattle trees, or rarely by indigenous shrub. Monocultures of weeping lovegrass (*Egrostis curvula*) and ryegrass (*Lolium perenne*) constituted the vegetation along the river banks in the farmland.

2.5 FAUNA

The following paragraph focuses mainly on the vertebrate species linked to the riverine habitat, but the presence of the freshwater crab, *Potamonautes depressus* (Rowe-Rowe, 1977a) has to be mentioned because of their relevance in the diet of the spotted-necked otter. Of 36 southern African fish families, only three families (7 species) are represented in the Drakensberg. Such a low species richness is due mainly to the fact that only a few indigenous fish species are suited to the cold mountain river and stream water. In the Mooi River, the indigenous fish population consists of the following species: scaly fish (*Barbus natalensis*), chubbyhead barb (*Barbus anoplus*), and mountain catfish (*Amphihinius natalensis*) (Coke M.[1], pers. com.; Skelton, 1993). Introduced brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) occur in the river and are regularly stocked in the dams in the Hatchery. Amphibian species recorded for the Kamberg area include *Rana angolensis*, *Bufo gutturalis* and *Xenopus laevis*. Almost 300 species of birds have been recorded in the Reserve (Cyrus & Robson, 1980). In the riverine habitat, and belonging to the Anatidae family, the Egyptian goose (*Alopochen aegyptiacus*), the African black duck (*Anas sparsa*) and the yellowbilled duck (*Anas undulata*) are very common. Partially sharing the trophic niche of the spotted-necked otters are different species of herons, among which the more common are the grey heron (*Ardea cinerea*) and the blackheaded heron (*Ardea melanocephala*), the reed cormorant (*Phalacrocorax africanus*) and a few kingfisher species, including the giant kingfisher (*Ceryle maxima*), the pied kingfisher (*Ceryle rudis*), and the halfcollared kingfisher (*Alcedo semitorquata*). Regarding mammals, Cape clawless otter (*Aonyx capensis*) and water mongoose (*Atilax paludinosus*) are fairly common in the Reserve, and partially share the habitat and prey categories of the spotted-necked otter (Rowe-Rowe, 1992a).

[1]Mike Coke, Natal Parks Board, Pietermaritzburg

2.6 HUMAN ACTIVITY

The effects on the riverine ecosystem of the past massive introduction of trout in the Natal Drakensberg rivers is widely recognized but not documented or quantified. Veld management methods adopted by the Natal Parks Board include a variety of burning schemes. Firebreaks are constantly mantained to limit the spread of uncontrolled fire. Periodical burning of grassland and wetland is performed, often including the vegetation along the river banks, in order to improve biodiversity and to reduce the chances of devastating runaway fires (Rowe-Rowe & Lowry, 1982). Degradation of the river banks and consequent erosion caused by pastures and cultivation in the rural village and on farmland affect the riverine habitat in terms of water quality and animal species variety. Legal harvesting of large wild mammals and of some birds is practiced by farmers. The killing of wild animals potentially interfering with farming, such as jackals, caracals, servals, mongooses and otters, is occasionally conducted in the farmland area. Unquantified illegal hunting was directly observed during the research project. Remains of hare (*Lepus saxatilis*) guts that had been cut with a knife were regularly found in the Stillerust area; parts of reedbuck (*Redunca arundinum*) unequivocally killed by humans were found on two occasions at the Hatchery and in the Stillerust area. The loss of one of the radio-tracked otters in the stretch of river in the rural village, and the subsequent finding of the radio in a hut, leads me to presume that there is hunting pressure on this species. No data are available on the impact of fish population exploitation by the rural community in the area.

CHAPTER 3 BIOLOGY OF THE SPECIES: BIBLIOGRAPHICAL REVIEW

3.1 INTRODUCTION

Literature regarding the spotted-necked otter is costituted mainly of studies conducted in the central African lakes, and the only information regarding the species ecology in riverine habitat is given by Rowe-Rowe (1977a;1992a;1992b). The following paragraphs summarize the different aspects of the biology of the species described in the available literature, identifying the main gaps in information on which research should be focused.

3.2 TAXONOMY AND DISTRIBUTION

Spotted-necked otters are classified in the family Mustelidae (order: Carnivora), sub-family Lutrinae, genus *Lutra*. Other species included in the genus *Lutra* are the Eurasian otter (*Lutra lutra*), the American river otter (*Lutra canadensis*), the sea cat (*Lutra felina*), the smooth-coated otter (*Lutra perspicillata*), the Neotropical otter (*Lutra longicaudis*), the Southern river otter (*Lutra provocax*), and the hairy-nosed otter (*Lutra sumatrana*). The distribution of the spotted-necked otter is limited to subsaharan Africa. Being an amphibious species, its presence is confined to freshwater habitats. Other species of otters occurring in Africa are the Cape clawless otter (*Aonyx capensis*), the Congo clawless otter (*Aonyx congica*) and the Eurasian otter (*Lutra lutra*) (Figure 3.1: compiled from data in Rowe-Rowe, 1990).

3.3 MORPHOLOGY

Like the other members of the sub-family Lutrinae, spotted-necked otters show the typical adaptations to an aquatic life. The body is slim and elongated, with a long dorsoventrally flattened tail. The head, broad at the back, narrows at the muzzle, and the ears are small and pressed close to the

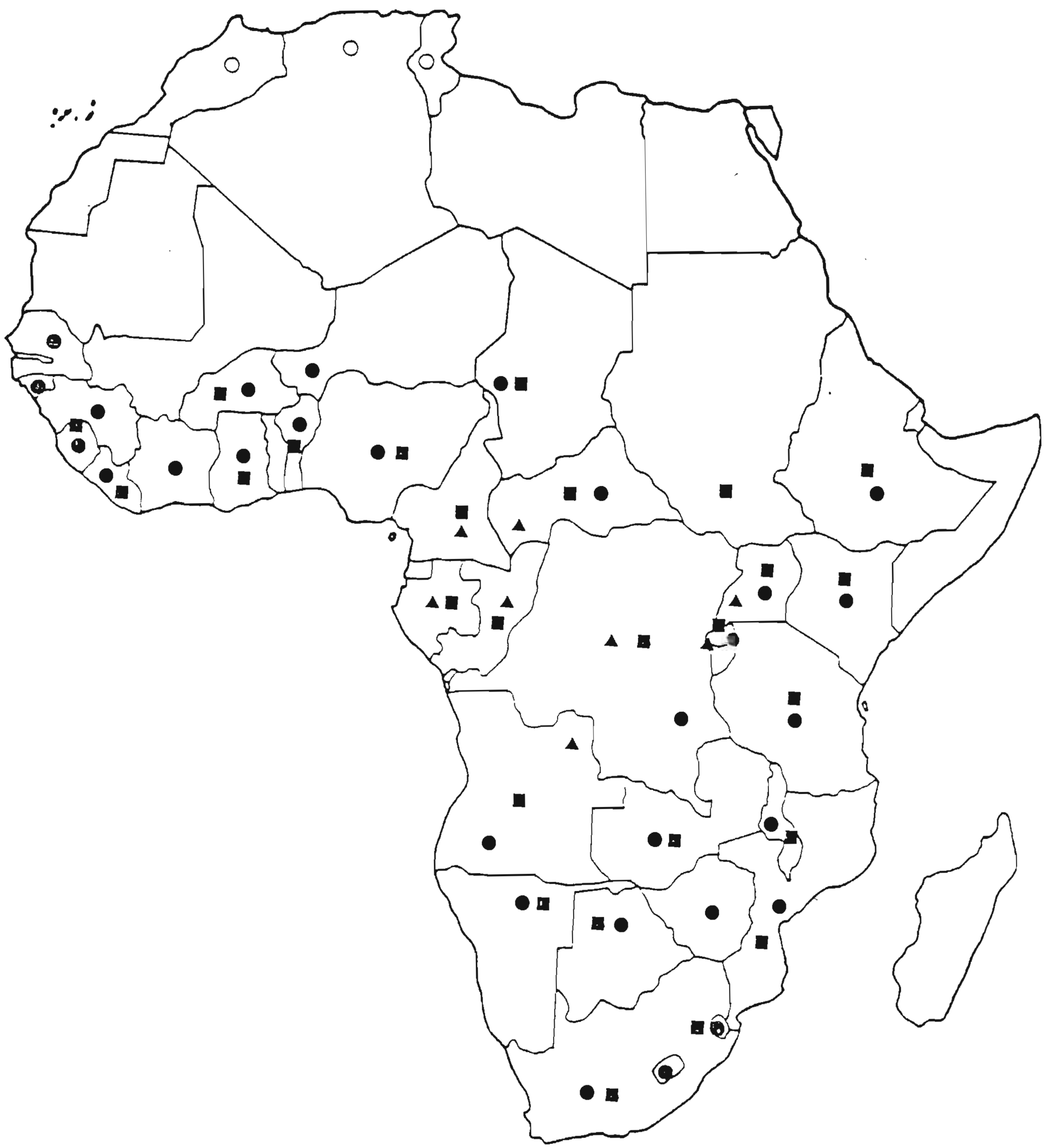

Figure 3.1 Distribution of *Aonyx capensis* (●), *Aonyx congica* (▲), *Lutra lutra* (○), and *Lutra maculicollis* (■) in Africa (compiled from data in Rowe-Rowe, 1990).

head. The feet are fully webbed. with short claws. The colour of the fur is generally dark brown. slightly lighter on the underside. The throat is caracterized by irregular patches and spots of cream or white. Because of the scarcity of specimens. neither neither a good sample of linear measurements nor body masses is available. As in all the other mustelids, males seem to be larger than females. Rowe-Rowe (1978) recorded the following average measurements:

total length	950-1170	mm
head-body length	575-690	mm
tail length	30-445	mm

The dental formula is:

$$I\ \frac{3}{3}\quad C\ \frac{1}{1}\quad P\ \frac{4}{3}\quad M\ \frac{1}{2}$$

The upper canines are sharp, the lower recurved, showing an adaptation to capturing and holding with the canines. The first premolars form a carnassial shear for biting off pieces of flesh. The other premolars and molar are flat. forming a crushing surface, but not as broad as in the Cape clawless otter. which is a specialist feeder on crustaceans (Rowe-Rowe, 1977a & 1977b).

3.4 HABITAT

Spotted-necked otters are confined to freshwater habitats, such as rivers, streams, lakes. and dams, preferring deeper water than the Cape clawless otter (Rowe-Rowe. 1978; Rowe-Rowe, 1992a). The presence of the species in estuarine or sea water has never been recorded. Information regarding habitat use has been collected mainly in the central African lakes (Lejeune & Frank, 1990; Kruuk & Goudswaard, 1990; Procter, 1963), while in riverine habitat the only information available is from Rowe-Rowe (1975; 1978; 1992a; 1992b) and Carugati (in prep.). Signs of presence have always been recorded close to the water's edge (Carugati, in prep.; Procter, 1963; Rowe-Rowe, 1978; Rowe-Rowe, 1992b). Holts, resting places and sprainting sites have been recorded mainly in dense vegetation, among tree roots or under tall grass (Carugati, in prep.; Rowe-Rowe, 1992b).

3.5 DIET

Considerable information concerning the feeding habits of the spotted-necked otter are available. In Central and East Africa, where the habitat is rich in fish, the spotted-necked otter's diet consists almost entirely of small fishes (Lejeune, 1990; Kruuk & Goudswaard, 1990), whereas in areas where the ichthyofauna is poor (midland and highland KwaZulu-Natal) the diet consists of almost equal proportions of crab and fish (Carugati, in prep; Rowe-Rowe, 1977a). Comparing the diet in a trout and in a non-trout area, Rowe-Rowe (1977a) found that fish together with crab was the main item in the first area, whereas in the non-trout area similar amounts of fish, crab and frog were eaten. The presence of crabs was much higher during spring and summer, when they were more available. In the trout-dominated area, 95% of the fishes were < 200 mm in length. The author related this phenomenon to two possibilities: first, smaller fishes were more abundant than were larger ones; second, smaller fishes are more easily caught than are larger ones and the otter is better adapted to deal with small prey (Rowe-Rowe, 1977b). Generally prey are eaten in the water, but in Lake Victoria Procter (1963) observed otters carrying larger fish to the lakes edge and eating them on the banks. Rowe-Rowe (1977b) observed similar behaviour in the wild and in individuals kept in captivity.

3.6 ACTIVITY RHYTHM

Spotted-necked otters are usually considered diurnal, being active mainly in the early morning and late afternoon (Lejeune, 1989; Procter, 1963; Rowe-Rowe, 1978 & 1992a). Lejeune (1989) recorded peaks of activity before 10h00.

3.7 SPACE USE AND INTRA-SPECIFIC RELATIONSHIPS

Spotted-necked otters were frequently observed in groups. In KwaZulu Natal, Rowe-Rowe (1978) recorded groups of up to five individuals, but more commonly 2-3 individuals per group. Groups of up to 20 individuals were observed by Procter (1963), who also recorded a group of six adult males. In Lake Victoria, Kruuk & Goudswaard (1990) noted groups of up to ten individuals, with an average group size of three individuals. In Lake Muhazi, Lejeune (1989) recorded 75% solitary individuals; groups generally consisted of two or three otters, sometimes larger, up to a maximum of 11. Cooperative hunting and prey sharing were not observed, although on some occasions Procter (1963) recorded an individual eating fish remains left by another otter.

Some information concerning the home range area of the spotted-necked otter in riverine habitat is given by Rowe-Rowe (1992b). Using signs of presence, he estimated densities of between 1 otter/6 km to 1 otter/11 km of river. Higher densites were estimated in central African lakes, where both Kruuk & Goudswaard (1990) and Procter (1963) estimated an average density of 1 otter/1 km along the lake shore, and Lejeune & Frank (1990) estimated 2 otters/km of lake shore.

3.8 REPRODUCTION

The only source of information is Procter (1963), and according to him the spotted-necked otter is a monoestrous species, producing one litter a year. Mating occurs in July (Lake Victoria), and the gestation period is sixty days. Litter size is up to three, most commonly two (Rowe-Rowe, 1992a). Nothing is known about parental care or dispersal.

3.9 COEXISTENCE WITH OTHER CARNIVORES: CAPE CLAWLESS OTTER AND WATER MONGOOSE

Signs of the presence of the three species in the same areas are commonly recorded (Kruuk & Goudswaard, 1990; Purves, Kruuk & Nel, 1994; Rowe-Rowe, 1992b; Somers, 1994). They share the same habitat, show temporal overlap in activity, and some prey items are common to all three species (Rowe-Rowe, 1977a). Water mongooses are considered the more opportunistic of the three species, changing diet and habits in relation to availability and environment (Skinner & Smithers, 1990). They are associated with an aquatic environment but make greater use of terrestrial habitats than do the two otter species. Signs of the presence of water mongooses have also been recorded far from water (Rowe-Rowe, 1978). Differences in hunting techniques between Cape clawless and spotted-necked otters were recorded by Rowe-Rowe (1977b): the former hunted more often in shallow water, using touch as the main sense in detecting prey, whereas the the latter species was observed in deep water, locating prey by sight. Even if the prey items are common to the two species, the relative importance of each category is sligthly different (Carugati, in prep.; Rowe-Rowe, 1978): Cape clawless otters feed mainly on crabs, supplemented with frogs and fish, while in KwaZulu-Natal spotted-necked otters feed on almost equal amounts of fish and crabs, supplemented with frogs (Rowe-Rowe, 1977a). In optimal habitat, such as the fish-rich central African lakes, the spotted-necked otter's diet comprises fish almost entirely.

3.10 PROBLEMS OF COEXISTENCE WITH HUMANS

The decline of the spotted-necked otter over its entire distributional range is mainly due to the increasing human population (Rowe-Rowe, 1990). Habitat alteration or loss, river pollution, as well as lack of natural resource conservation are direct consequences of human activities. Spotted-necked otters are expecially persecuted. During the current research many instances of persecution, perpetrated mainly by fish-farmers, were noted, as was the hunting of otters by subsistence farmers, using dogs. Since otters sometimes exploit stocked dams, they are commonly trapped and killed. Skins and other parts of the body are occasionally used as traditional medicines, as documented by Cunningham & Zondi (1991) and Rowe-Rowe (1992a).

CHAPTER 4 CAPTURE, IMMOBILIZATION, AND MEASUREMENTS

4.1 INTRODUCTION

Live-trapping of otters, like most of the mustelids, is generally very difficult, and only a few studies involving captures have been carried out. With the exception of the sea otter (*Enhydra lutris*) (Garshelis, 1984), otters have been captured mainly in mesh box traps baited with fish (e.g. Melquist & Hornocker, 1983; Northcott & Slade, 1976). In southern Africa, Cape clawless otters were captured by Van der Zee (1981) and Arden-Clarke (1986). Both authors used mesh box traps, with single or double door, baited with fish. Captures of spotted-necked otters have not previously been recorded in the literature.

4.2 MATERIALS AND METHODS

The animals were captured in standard carnivore traps (800x800x1400 mm) with a single door (Arden-Clarke, 1986; Van der Zee, 1982). This type of trap minimizes the risk of injuries to the animal during capture, as well as between capture and the administration of the anaesthetic. Traps were placed where fresh and constant signs of the presence of spotted-necked otters were recorded, along river banks, dams or oxbow lakes, and positioned so that the entrance was always facing the water.

Two different baits were used simultaneously; fresh fish (e.g. Arden-Clarke, 1986; Melquist & Hornocker, 1983; Shirley, Linscombe & Sevin, 1983; Van der Zee, 1981) and white chicken or duck feathers hung on the trap to arouse curiosity (sight). Traps were checked early every morning. Captured otters were pushed from the trap into a hessian bag, weighed on a spring balance, and anaesthetised with ketamine hydrochloride (Ketalar, Parke Davis, 50 mg/ml; 0.1-0.2 ml/kg) (Arnemo, 1991; Arden-Clarke, 1986; Van der Zee, 1982).

For each animal the following lenght were recorded:

- body mass
- head and body length
- tail length
- hind foot *(cu)* length
- ear length

Sex and reproductive status (pregnancy, signs of lactation, abdominal or scrotal testes) were recorded. It was impossible to determine the age of the animals, as the only method that gives a precise estimation of age is the analysis of the tooth cementum annuli (Garshelis, 1984; Stephenson, 1977; Matson, Dix & Strickland, 1991), that required the extraction of a tooth, and pulp cavity radiography (Marchesi,1989), which does not cause permanent physical damage to the animal, but requires keeping the animal in captivity for a long time.

The animals were classified as adults, subadults (yearlings), or juveniles according to body mass, reproductive condition (evidence of lactation, enlarged testes), and tooth wear (e.g. Melquist & Hornoker, 1983).

The general physical condition of the animal and the presence of ectoparasites were recorded following handling. For each individual a photograph of the neck was taken, since the pattern of the spots varies individually, and can be useful in recognising animals individually, during observation or if recaptured. Each animal was fitted with an intraperitoneal radio-implant (chapter 5). Surgical operation was performed up to 3,30 hours after the subministration of the first dose of anaesthetic.

Animals were kept in a wooden box until completely recovered from the anaesthetic (maximum eight hours following surgery), and then released at the site of capture.

Differences in size in the two sexes were tested using Wilcoxon Mann-Whitney U test.

4.3 RESULTS

From June 1994 to February 1995 nine trapping sessions were conducted comprising 410 trap nights. Seven individual spotted-necked otters, four males and three females, were captured (Table 4.1).

The trapping success was one per 58,6 trap nights. Individuals of the following species were also captured: large grey mongoose (*Herpestes ichneumon*) (2 captures), water mongoose (1 capture), Cape clawless otter (2 captures), and serval (*Felis serval*) (1 capture).

The spotted-necked otters captured were all considered adults except for M5, which was classified as a yearling. The measurements of each individual are reported in Table 4.3. The average measurements of adult males and females were calculated. The average body mass was 5,5 kg for males and 4,3 kg for females; the average head and body length was 710 mm for males and 585 mm for females. Differences in size between males and females were statistically significant (body mass: Wilcoxon Mann-Whitney U Test: U=1, P(U<=*a*)=0,057; body length: Wilcoxon Mann-Whitney U Test: U=0, P(U<=*a*)=0,028.

DISCUSSION

Since it is the first time that spotted-necked otters have been captured, it is not possible to compare the recorded trapping success with previous studies. Trapping success decreased session by session (36,0 trap nights per otter during the first 4 months; 81,2 trap nights per otter during the following 5 months). The first trapping sessions took place in winter, when food was less available and the animals were more attracted to the bait.

Another factor which may have possibly played a role in the higher trapping success recorded during the first four months of the study is that winter coincides with the mating season, when activity and movements increase and consequently the chance of capture. Furthermore, since spotted-necked otters occur in pairs or groups most of the time, the sight of an individual in the trap could have negatively affected the trappability of the other members of the group. Cape clawless otters were captured by Van der Zee (1982) and Arden-Clarke (1986) with a much higher trapping success (14,6 trap nights per otter and 12.5 trap nigths per otter respectively), but in a completely different habitat.

Table 4.1 Captures, anaesthetic doses, and morphometrical measurements of spotted-necked otters (June 1994-February 1995).

animal	age	date of capture	ketamine dose (mg/kg)	hours kept in captivity	body mass (kg)	head & body (mm)	tail (mm)	hind-foot (cu) (mm)	ear (mm)
Males									
M5	yearling	08/08/94	2,4	11h55	4,50	650	380	113	17
M4	adult	05/08/94	1,9	11h30	5,70	710	385	120	18
M1	adult	28/06/94	1,9	10h35	5,80	720	430	154	17
M7	adult	10/11/94	1,9	11h05	6,00	760	440	122	21
mean					***5,50***	***710***	***409***	***127***	***18***
Females									
F3	adult	30/06/94	2,4	10h10	3,80	570	440	111	15
F2	adult	28/06/94	1,5	8h35	4,40	605	440	115	20
F6	adult	13/09/94	1,9	11h30	4,70	580	410	114	18
mean					***4,30***	***585***	***430***	***113,3***	***17,6***

WILCOXON MANN-WHITNEY U TEST

Body mass: U=1, P(U<=a)=0,057
Body length: U=0, P(U<=a)=0,028

Differences in body mass and size between males and females are commonly found in mustelids. There are two main explanations for the selective advantages of sexual dimorphism. The first hypothesis recognizes that differences in body size minimize intersexual competition for food, since each sex exploits different prey (Brown & Lasiewski, 1972). Data available on food habits are, however, insufficient to prove or negate that theory. A second and more accredited hypothesis recognises that males and females are under different selective pressures. The main aim of a female is reproductive success, and a smaller body requires less total energy for daily mantenance which allows it to channel relatively more energy into reproduction than larger males (Moors, 1980).

CHAPTER 5 HABITAT USE AND SELECTION

5.1 INTRODUCTION

Most animals have certain habitat requirements and are more likely to be found in one habitat than in another (Dixon & Chapman, 1980). The aim of this study was to identify habitats necessary for the presence of the spotted-necked otter. The use of habitats is estimated as the percentage of time the animal spends in them (Johnson, 1980; White & Garrott, 1990). The time an animal is expected to spend in each habitat category is proportional to the availability of each category: if the time spent in a particular habitat category is more (or less) than the expected, the animal displays a selection.

Availability consists of the area of each habitat category effectively available to the animals. Factors determining habitat use are numerous and different for each species studied. Human disturbance, roads, and absence of corridors, are some of the factors that may affect the accessibility to potentially suitable areas. Territoriality, that is the active defence by conspecifics of the area used by an animal, is another factor to consider in evaluating availability (White & Garrott, 1991): in territorial species, a suitable area may not be accessible to an animal because it is already occupied by a conspecific.

Observations in nature of spotted necked otters documented in the literature suggest that the species is social; data collected during this research confirm the tendency of this species to demonstrate different degrees of sociality, which are strictly related to resource availability. In the following analysis the area included by the perimeter defined by summing the home ranges of all of the animals radio tracked was considered as potentially available (White & Garrott, 1990), while use was determined by means of radio telemetry.

Habitat use is determined in an animal mainly by the following needs: resting, feeding, and reproduction. The habitat characteristics required for the first and the last activity are generally different from the ones required for feeding. Thus, habitat use and selection during activity and during inactivity were analysed separately.

5.2 MATERIALS AND METHODS

5.2.1 ANIMAL MARKING

Each animal captured was marked with an intraperitoneal radio implant (Mod Imp300. Telonics Inc., Mesa, Arizona). Radio implants have been successfully use on a wide range of species such as mink (*Mustela vison*), raccoon (*Procyon lotor*), and other otter species (Melquist & Hornocker, 1983; Arnemo, 1993; Arden-Clarke, 1986).

External devices on amphibious mammals are more likely to affect survival rate of marked animals, as they can easily be snagged by other objects under water while diving. Radio-collars are also more difficult to apply on otters because of the fusiform shape of the body. The choice of a radio implant depends on the duration on life of the battery, and on the pulse rate (numbers of pulses per minute). A high pulse rate helps in capturing the signals of an animal in movement, causing a faster consumption of the battery. Considering that the mass of the radio implant is mainly determined by the battery size, and must not exceed 3-5 % of the body mass of the animal (Macdonald & Amlaner, 1980), a compromise between transmitter life and pulse rate is necessary. In this research radio implants weighing 30 g (0.5-1 % of the weight of the animal) with an expected life of 10-13 months and a rate of 40-60 pulses/min were used.

5.2.2 RADIOTELEMETRY

Radiotelemetry consists in the use of a transmitting system and a receiving system. The transmitting system is the radio implant. The implant comprises a radio transmitter, emitting a signal in the form of pulses, a battery, and an aerial to transmit the signal through the air. The whole transmitting system is coated in a hypoallergic material that minimizes the risks of rejection by the animal. The receiving system consists of a radio receiver, that captures the signals emitted by the transmitter transforming them into sonic signals, and a directional aerial, that enables determination of the direction of the captured signals.

Radiotelemetry enables the determination of an animal's position. Position is determined by triangulation, requiring capture of the signals from at least two directional sites (Mech, 1983). Bearings are recorded on a map of the study area. The position of the transmitter (animal) is given by the intersection of the bearings. Considering that the aerial detects the direction from which the signal is emitted with an error, the intersection is not a precise point but a polygon called an "error polygon" (White & Garrot, 1991). The intensity of the signal varies with the activity of the animal, being regular when the animal is resting, and irregular when it is moving (Voigt & Tinline, 1979). When the animal is resting, obstacles obstructing the signals are constant, and the radio receiver captures the signal in the form of pulses with constant intensity. When the animal is moving, the position of the aerial of the radio transmitter and the obstacles intercepting the emanating signal changes continuously, so that the intensity of the pulses captured by the receiver is not constant. Since each radio transmits on a specific frequency (between 146 and 147 MHz), animals are recognised individually.

A four element Yagi antenna with a Yaesu Mod 2F radio was used for the receiver. Animals were located on a 1:10000 orthophoto map (Director General of Surveys).

5.2.3 DATA COLLECTION

5.2.3.1 RADIOTELEMETRY

Data collection was conducted regularly for 16 months (two weeks every month). Both single locations (fixes) and 24 hours continuous tracking sessions (in which animals were located every fifteen minutes) were performed each month. Each animal was located during the day every 6-8 hours. Furthermore, they were tracked continuously for a 24 hours period once a month.

Positions were reported on a map on which was overlayed a 55 m (2,27 seconds, Planetary Coordinate System) grid. According to White & Garrott (1991), the positions of the animals were reported as occurring in the square of the grid in which the polygons resulting from the triangulations occurred.

For each fix the informations reported in Table 5.1 were recorded. Temperature and rainfall data were available from the Natal Parks Board metereological station in Kamberg Nature Reserve.

5.2.3.2 HABITAT AVAILABILITY

A vegetation map of the study area was not available. Field surveys were conducted in each of the squares of the grid in which animals were located. The survey plots were 10 m^2. Habitat categories were recorded as a percentage of the survey plots which they occupied.

5.2.4 DATA ANALYSIS

5.2.4.1 INDEPENDENCY OF OBSERVATIONS

Analysis of radio-tracking was performed using a sample of independent observations (White & Garrott, 1990). If animal M1 at time t is in habitat A, the chance of locating it at time t+dt in a habitat different from A increases with an increase in dt. Two observations can be considered independent if separated by an adequate interval of time (Swihart & Slade, 1985). That interval can be estimated by calculating the average time an animal needs to reach the two farthest points of its home range (White & Garrott, 1990). That time was calculated based on the average speed recorded during the continuous tracking sessions. The average speed obtained for males was 8,1 km/h, and for females 6,5 km/h. Since the distance between the two furthest points of the largest home range was about 24 km, observations were therefore considered to be independent if separated by at least 4 hours.

5.2.4.2 HABITAT USE

Overall habitat use was calculated as the percentage of observations recorded in each habitat category. Since spotted-necked otters are strictly tied to the aquatic environment (Chanin, 1985; Rowe-Rowe, 1992a), and feeding

Table 5.1 Example of a field data sheet.

DATE	ANIMAL	TIME
ACTIVITY: 1) resting 2) moving 3) travelling		**SOIL:** 1) dry 2) moist 3) wet 4) frost
WIND: 1) absent 2) weak 3) medium 4) strong		**RAIN:** 1) absent 2) weak 3) medium 4) strong 4) snow
LIGHT: 1) day 2) night 3) twilight		**MOON:** 1) absent 2) 1/4 3) 1/2 4) 3/4 5) full
ASSOCIATION WITH CONSPECIFICS:	numbers of individuals sex	
HABITAT:	**RESTING** 1) tree 2) reeds 3) grasses 4) rocks 5) swamp 6) island	**ACTIVE** 1) river 2) dam 3) oxbow lake 4) stream 5) swamp

occurs entirely on aquatic species (Carugati, in prep.; Lejeune, 1990; Kruuk & Goudswaard, 1990; Rowe-Rowe, 1977a), a comparison was made of habitat use during the wet and dry season.

As already described in chapter 2, Kamberg Nature Reserve includes a trout hatchery and several dams regularly stocked with trout. A comparison of the habitat use in the trout Hatchery area and in the Stillerust area, in which food availability is natural, was also performed.

5.2.4.3 HABITAT SELECTION

Bonferroni confidence intervals in conjunction with a goodness-of-fit tests were employed to determine habitat selection (Neu, Byers & Peek, 1974; Byers, Steinhorst & Krausman, 1984; White & Garrott, 1990; Aldredge & Ratti, 1986):

$$\bar{P}_i - Z_a/Z_k \left(\frac{\bar{P}_i(1-\bar{P}_i)}{n}\right)^{1/2} <= P_i =< \bar{P}_i + Z_a/Z_k \left(\frac{\bar{P}_i(1-\bar{P}_i)}{n}\right)^{1/2}$$

P_i =proportion of habitat $_i$ available

$\bar{P}_i$ =proportion of time spent in habitat $_i$

$Z_a/2_k$ =standardized normal variable corresponding to $a/2k$ probability tail area

To determine whether a habitat is avoided or preferred, the confidence interval is checked for overlap with the available proportion of the corresponding habitat. If the confidence interval includes the available proportion, then the hypothesis of no preference or avoidance of this habitat cannot be rejected. Differences between use and availability were considered significant when $p<0.05$. Contingency tables were drawn up in order to test seasonal differences in the habitat use as well as between the Hatchery and the Stillerust areas. Differences were considered significant when $p<0.05$.

5.3 RESULTS

From the 10560 records collected, a sample of 1271 independent locations was used for the radio tracking data analysis.

5.3.1 HABITAT AVAILABILITY

The area considered as available was delimited by the perimeter including the home-ranges of all the radio-tracked otters. Protected areas constituted 52% (the Hatchery 30%; Stillerust 22%) of the available area, while unprotected areas constituted 48% (Tendele village 26%, Riverside farm 22%). Availability of the aquatic habitat categories was not quantified. The area considered as available extended along the Mooi River catchment, and all the plots in which habitat availability was estimated included aquatic habitats. Dams were almost entirely confined to the Hatchery, except for one dam situated on farmland (Riverside) adjacent to the Stillerust area, that was regularly used by the otter F3. Oxbow lakes were, on the other hand, mainly situated at Stillerust, and, as already reported (Rowe-Rowe 1977a), only two of them are permanent. A small oxbow lake is situated between the river and one of the dams at the Hatchery. There are many minor tributary streams along the Mooi River in the study area.

'Grasses' is the most common habitat category (62%). It is the main vegetation cover along the dam banks, in the village and on the farmland (where it often occurs not as tall indigenous grasses, but as pastures), and, except for the first stretch, at Stillerust. Trees (19%) occurred mainly along the river banks in the Hatchery area and in the first stretch of river at Stillerust. Reeds (9%) were represented mainly in the dams, but also along the river, while rocks (0,7%) were found mainly along the river, particularly at the intersection with tributaries. Most of the swamps (10%) were in proximity of the dams and the oxbow lakes, whereas the presence of islands (0,02%) was limited to the dams.

5.3.2 HABITAT USE AND HABITAT SELECTION

Ninety-five per cent of the observations were made inside the two protected areas constituting Kamberg Nature Reserve, while only 5% were made in the stretch of river flowing through the rural village and the farm (Figure 5.1).

Animals were generally found in unprotected areas mainly while travelling between the two protected areas. Protected areas were strongly selected for ($p<0.001$), while unprotected areas were avoided ($p<0.001$). Bonferroni intervals of confidence are reported in Appendix 1, Table 1.

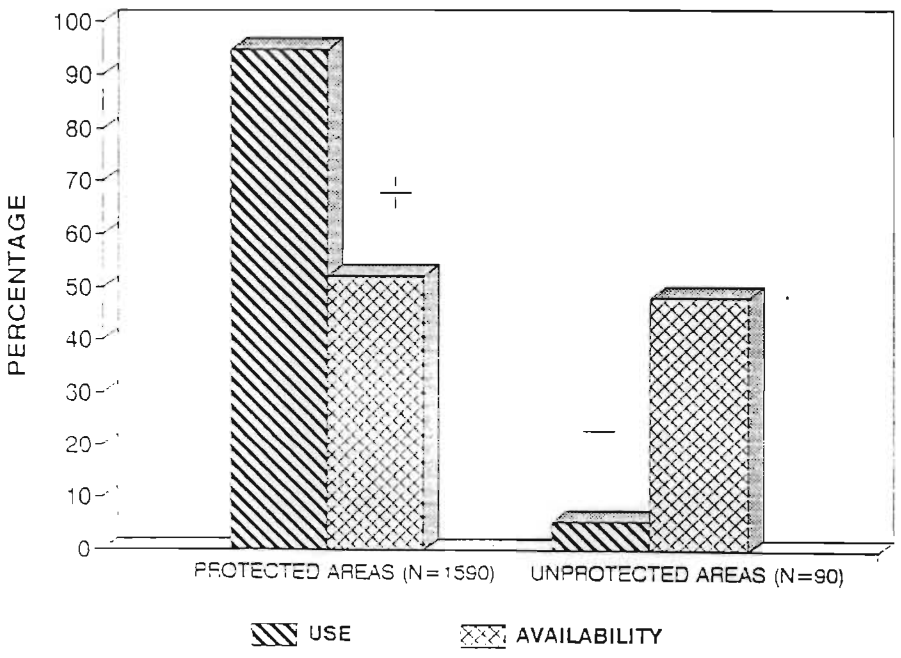

Figure 5.1 Use of protected and unprotected areas (the symbol '+' indicates preference, '-' avoidance).

5.3.2.1 HABITAT USE AND SELECTION WHILE RESTING: OVERALL ANALYSIS

The sample of independent locations in which animals were classified as resting numbered 974. All of the observations were recorded along the banks of the aquatic habitats also used during activity.

Animals were found mainly while resting in holes among tree or shrubs roots (29%), reeds (21%), or small islands in the dams (23%). Tall grass (14%), swamps (11%) and sheltered places among rocks (2%) were also used occasionally (Figure 5.2). Considering all of the habitats simultaneously, otters did not use habitats in proportion to their availability (Chi-square=199276; $p<0.001$). Among the habitat categories mentioned above, trees and shrubs, reeds, and islands were strongly preferred ($p<0,001$), while grassland was avoided ($p<0,001$). Although available at very low density, rocks were preferred ($p<0,001$). The use of swamps did not differ significantly from expected. Bonferroni intervals of confidence are reported in Appendix 1, Table 2.

At Stillerust the otters used grassland significantly more than at the Hatchery (Chi-square=341.18; $p<0,001$). The use of islands was not recorded at Stillerust because that habitat category was not represented in that area. The other habitat categories were used in the two areas in similar proportions (Figure 5.3). A contingency table is provided in Appendix 1, Table 4.

5.3.2.2 HABITAT USE AND SELECTION WHILE RESTING: SEASONAL ANALYSIS

Samples used for seasonal analysis constituted 445 observations from the wet season and 529 observations from the dry season. Significant differences in seasonal habitat use were found when considering all the habitats simultaneously (Chi-square=116,3; $p<0,001$). The habitat categories used in similar proportion during both wet and dry seasons were trees and shrubs (wet season=32%, dry season=26%; Chi-square=2,88), reeds (wet season=24%, dry season=17%; Chi-square=5,9), and rocks (wet season =1%, dry season=3%; Chi

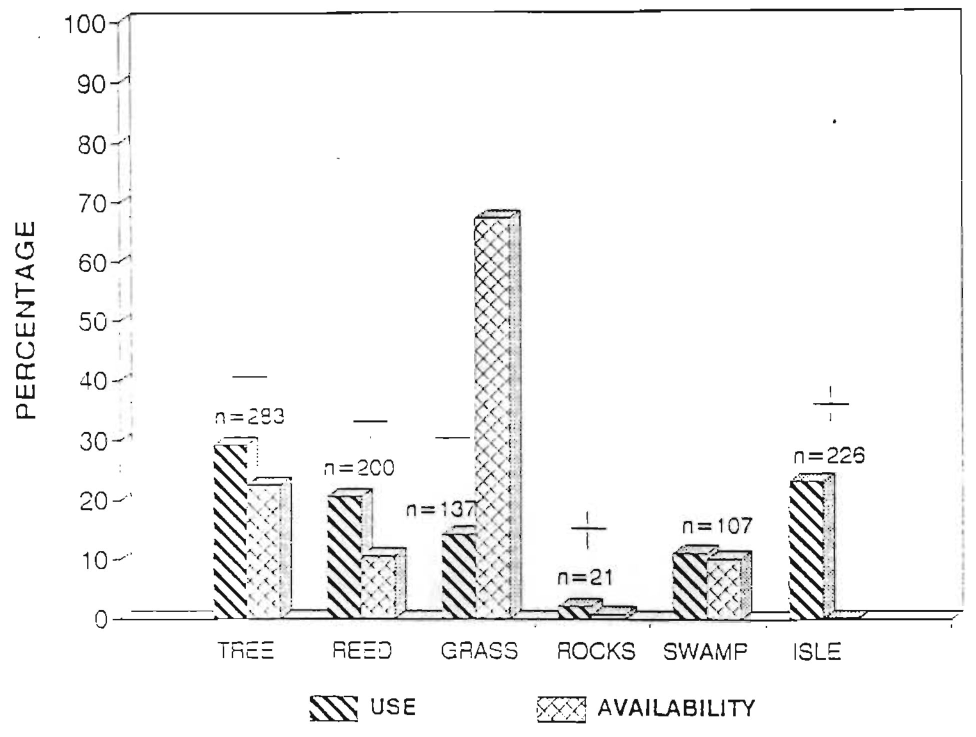

Figure 5.2 Habitat use while resting: overall analysis (the symbol '+' indicates preference, '-' avoidance).

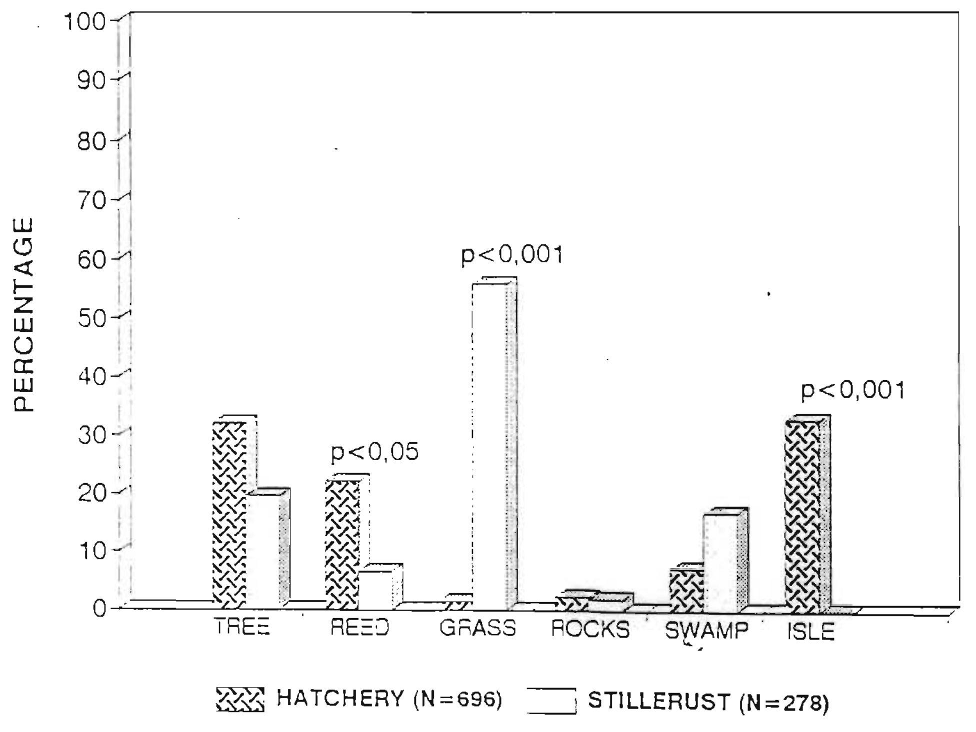

Figure 5.3 Habitat use while resting: a comparison between the Hatchery and Stillerust areas.

-square=1,3). The use of swamps and islands decreased significantly in the wet season (swamps: Chi-square=35,9; p<0,001; islands: Chi-square=24,7; p<0,001). Use of the grassland, however, increased significantly during the wet season (Chi-square=45,66; p<0,001) (Figure 5.4). A contingency table is reported in Appendix 1, Table 5.

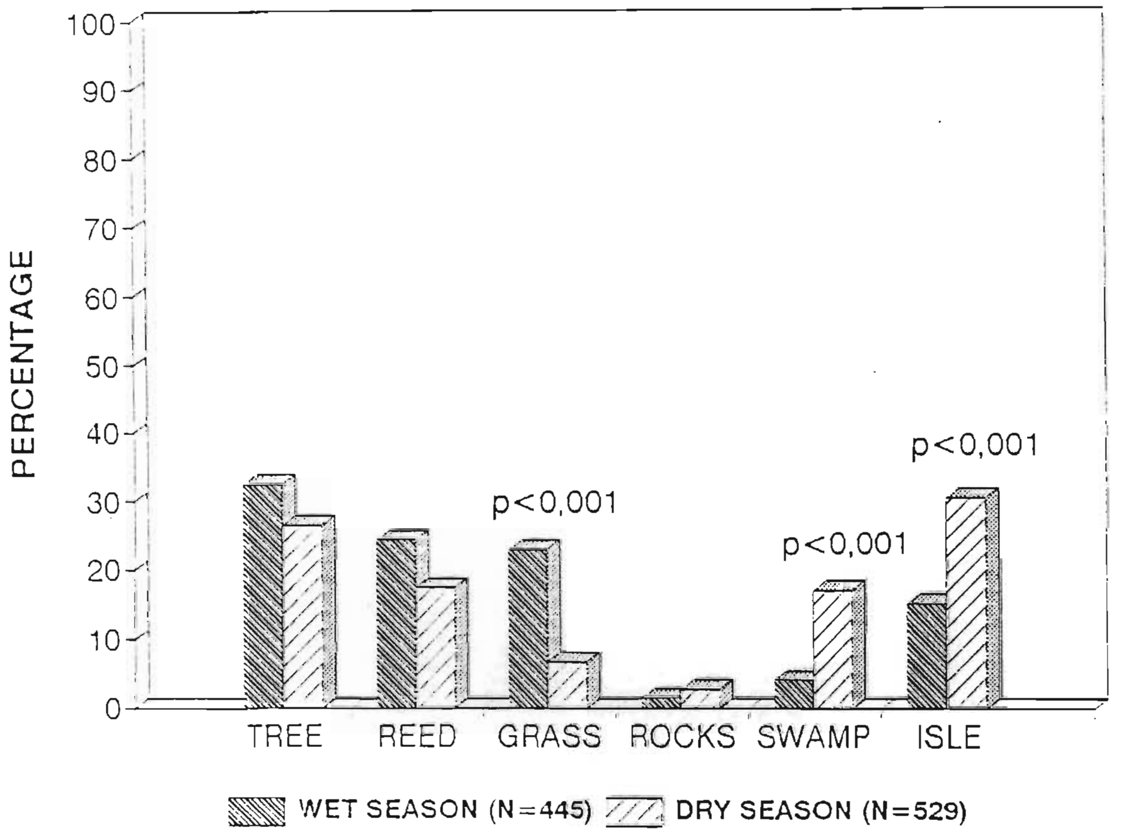

Figure 5.4 Habitat use while resting: a comparison between the wet and dry seasons.

5.3.2.3 HABITAT USE AND SELECTION DURING ACTIVITY: OVERALL ANALYSIS

Animals were recorded as active during 706 independent locations. River (40%) and dams (45%) were the aquatic habitat categories where otters spent most of their time while active. Oxbow lakes (10%), streams (2%) and swamps (3%) were also used (Figure 5.5).

The significantly higher use of dams at the Hatchery (Chi-square=69,7;p<0,001) and the significantly higher use of oxbow lakes at Stillerust (Chi-square=190.18;p<0,001) were due to the different availability of these habitat categories in the two areas (Figure 5.6).

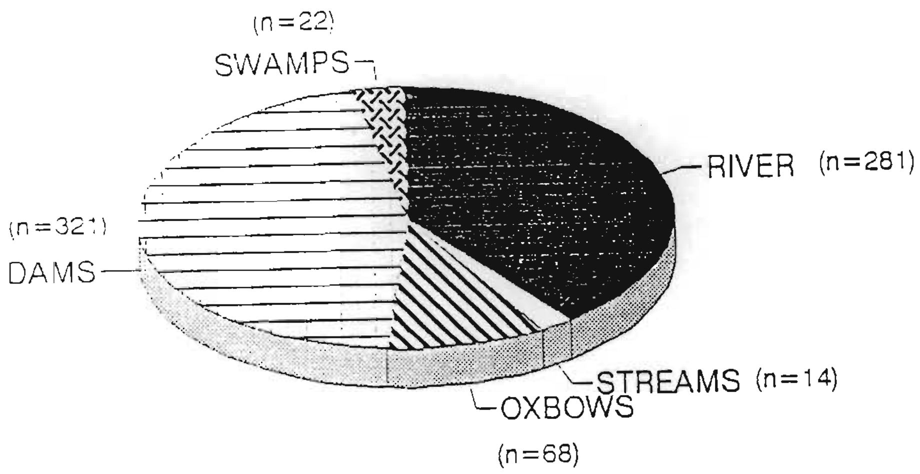

Figure 5.5 Habitat use during activity: overall analysis (N=706).

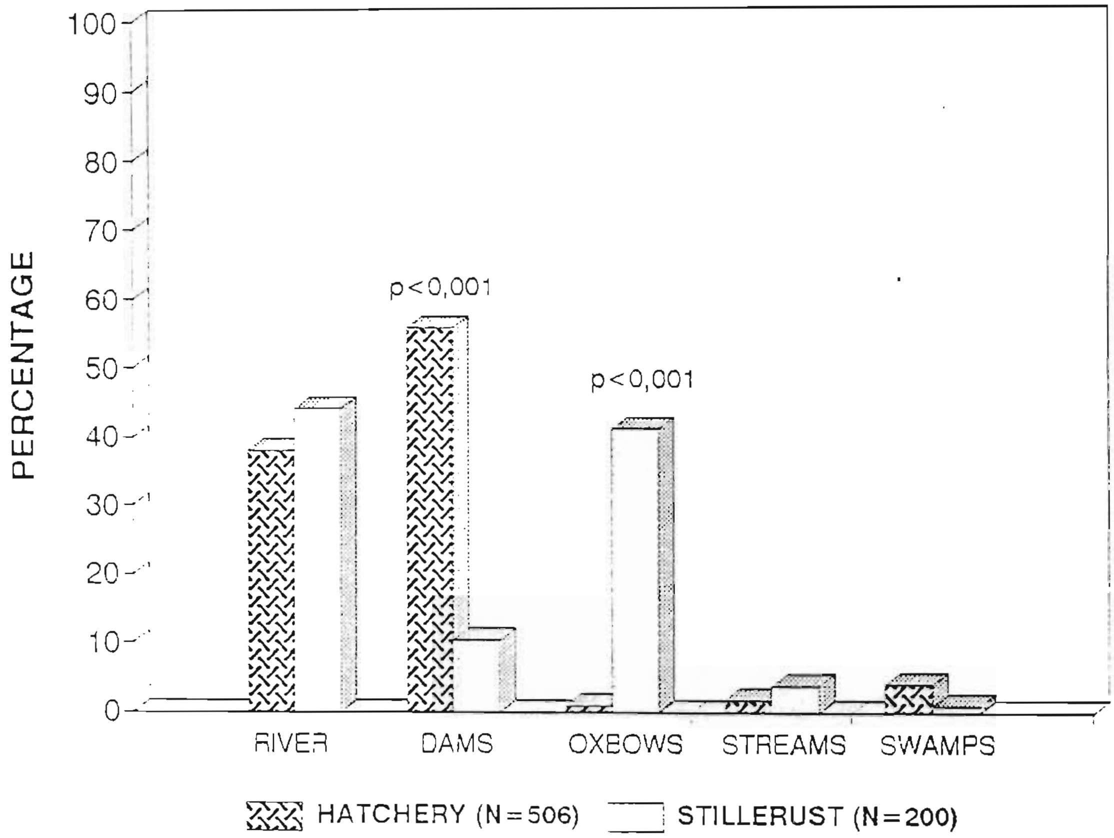

Figure 5.6 Habitat use during activity: a comparison between the Hatchery and Stillerust areas.

5.3.2.4 HABITAT USE DURING ACTIVITY: SEASONAL ANALYSIS

Samples used for seasonal analysis constituted 330 observations for the wet season and 376 observations for the dry season. Considering all habitat categories simultaneously, significant differences were found between the wet and dry seasons (Chi-square=32,2; p<0,01). During the wet season, otters used riverine habitat significantly more than during the dry season (Chi-square=12.5: p<0.01). Presence in swamps was, however, significantly higher in the dry season (Chi-square=9,7; p<0,05). Use of dams (wet season=41%, dry season=50%; Chi-square=1,27), oxbows (wet season=9%, dry season=10%; Chi-square=0.08), and streams (wet season =0,4%, dry season =3%; Chi-square=5,4) did not show significant seasonal differences (Figure 5.7). A contingency table is reported in Appendix 1, Table 7.

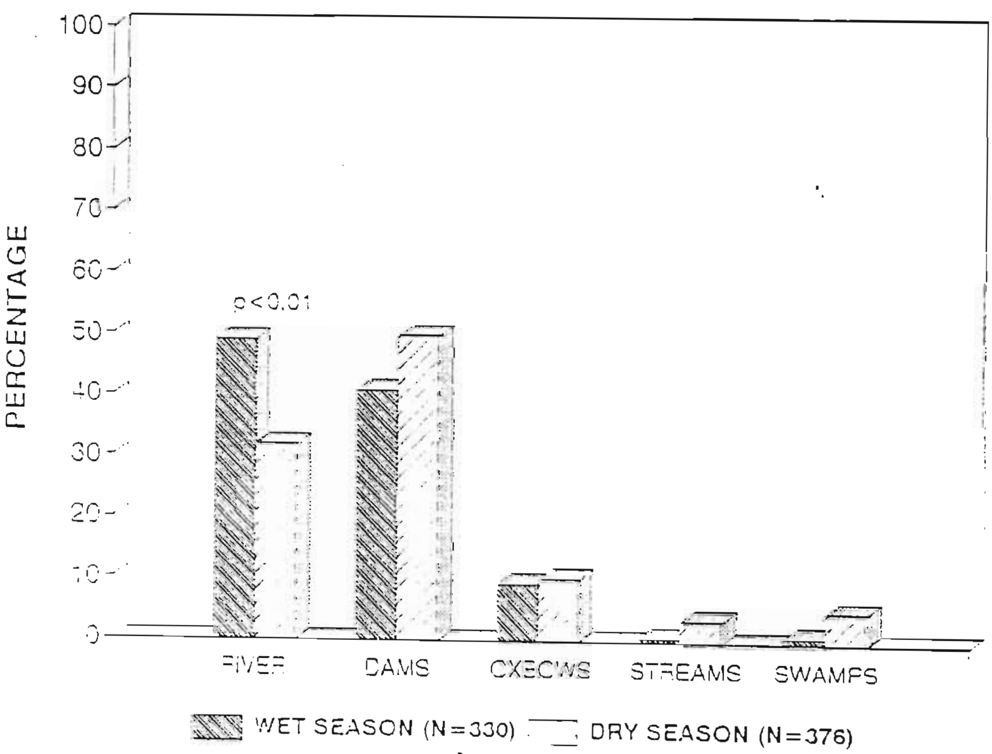

Figure 5.7 Habitat use during activity: a comparison between the wet and dry seasons.

5.4 DISCUSSION

5.4.1 HABITAT USE WHILE RESTING

River bank vegetation cover and human disturbance were the main factors determining the presence of spotted-necked otters. Animals almost totally avoided the stretch of river flowing through the rural village and the farm, using it only as a corridor to move between the two protected areas (Hatchery and Stillerust areas). The river both in the village and in the farmland was characterized by very poor vegetation cover, constituted mainly by sporadic alien trees (wattle and willow trees), and adequate sheltered resting places were not available; pastures and cultivations extended right to the river banks, causing bank erosion and consequently increasing river bank height and silting of the water. Human disturbance occurred mainly in the stretch of river flowing through the rural village, where local people were constantly by the river during the day. Active persecution of otters is occasionally practised, as confirmed by the death of a radio-tracked animal in that stretch of the river.

The importance of vegetation cover has already been underlined by other authors. Rowe-Rowe (1992b) found in Kamberg Nature Reserve that most of the sprainting sites of the two otters species which occur in the area were associated with adequate vegetation cover, and resting places, that were mainly holes among tree roots or among rocks, or in very secluded places such as islands. In Lake Victoria, Procter (1963) also observed that bank cover was an important factor determining the presence of otters. Investigating the reasons for the decline of spotted-necked otters in Lake Victoria, Kruuk & Goudswaard (1990) observed that otters were almost absent in a section of the lake with a high density of human settlements, where vegetation along the banks was very poor and human disturbance was high, whereas most of the signs of presence were found on remote islands and in a section of the lake with banks covered with indigenous bush. Information given by Lejeune & Frank (1990) on habitat use of the species in lake Muhazi (Rwanda) confirmed what is described above.

Animals were always found resting on the banks of the aquatic habitats used during activity, at sites directly reachable from the water, as Rowe-Rowe (1992b) and Procter (1963) have already reported. The species is confined to freshwater habitats, and is much less likely to move away from water than is the Cape clawless otter. Differences in the habitat use between the Hatchery and Stillerust areas were mainly caused by the different availability of the habitat categories in the two areas. Tall grass and swamps were the main vegetation cover along the oxbow lake banks at Stillerust, while in that area no islands were available. Reeds occurred in most of the dams at the Hatchery, while sporadically along the river banks at Stillerust. The decrease in the use of islands and reeds in the wet season and the parallel increase of the use of trees and rocks is probably explained by the higher presence of otters in the river in that season, and the less intense use of dams. Reeds and islands occur mainly in the dams, while rocks and trees occur mainly in the river. As will be discussed in detail in paragraph 5.4.2, the main explanation for the change in the use of habitat categories is related to the higher use of the river in the wet season as a result of the higher productivity of the river in that season. The higher use of trees and rocks may be attributed to the fact that part of the wet season coincides with the breeding season, and holes among tree roots or among rocks offered a safe place for a holt. This hypothesis is supported by the behaviour of the female F2, whose activity was markedly reduced during September and October. This leads me to suppose that she had cubs, and regularly used only one resting place situated at the intersection between a tributary stream and the river, among rocks.

The higher use of grassland during the wet season was probably due to the fact that with the capture of F6, the number of resident radio-tracked animals in the Stillerust area increased from 1 to 2. As described above, grassland consituted the main cover along the oxbow lake banks, that are common in that area.

During the wet season swamps were often completely covered by water, so that for the animals it was more difficult to find an adequate resting place.

5.4.2 HABITAT USE IN ACTIVITY

Spotted-necked otters typically show adaptations to acquatic life, having a slim and elongated body, a dorsoventral flattened tail and feet fully webbed. In the highly productive lakes of central Africa, its diet consists almost entirely of fish (Lejeune, 1990; Procter, 1963; Kruuk & Goudswaard, 1990). The poor productivity of the rivers in the Natal Drakensberg is probably the reason for the broader trophic niche of the spotted-necked otter (Carugati, in prep.; Rowe-Rowe, 1977a), and also explains the consistent activity in swamps, where the availability of crabs, frogs, and insects was elevated. During the wet season the use of dams decreased drastically, together with the increase of crab, frog, and insects in the diet (Carugati, in prep.; Rowe-Rowe, 1977a). That phenomenon can be explained by the poor productivity of the Mooi River in terms of fish. Otters in the river foraged mainly for crabs, frogs, and insect larvae. Crabs hibernated in winter (dry season), becoming an almost inaccessible resource, and insect larvae were also not available during that season. This explanation may seem to contradict the fact that the spotted-necked otter is primarily a piscivorous species, but based on the observations conducted by Rowe-Rowe (1977c) on the predatory behaviour of the Cape clawless otter, it can be hypothized that the alien introduced trout is a difficult prey for otters, and is exploited mainly when easier prey items are less available. The hypothesis is supported by what Rowe-Rowe (1977c) observed, when studying the Cape clawless otter diet in a trout and in a non-trout area. The amount of fish in the Cape clawless otter's diet in a non-trout area was constant throughout the year, whereas in a trout area it was not. Carugati[1] (pers. com.) has similar results for the spotted-necked otter in Kamberg Nature Reserve, with comparisons of the seasonal diet in the Hatchery and in the Stillerust areas. The constant seasonal use of the oxbow lakes, that are situated in a non-trout area, and where the fish population comprised indigenous species, confirms that, if available, indigenuous fish species are preyed upon constantly by spotted-necked otters, while an introduced alien species such as the trout, was more difficult prey,

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and was only preyed on when alternative food resources were scarcely available.

CHAPTER 6 ACTIVITY RHYTHMS

6.1 INTRODUCTION

Here, the use of time budgets by the spotted-necked otter is considered. One of the main factors determining activity patterns in predators is synchrony with the activity of their prey. This has been shown in many terrestrial predators such as mink *Mustela vison* (Gerrell, 1969; Melquist, Whitman, Hornocker, 1981;), American marten *Martes pennantii* (Powell & Zielinski, 1983), European fox *Vulpes vulpes* (Cavallini & Lovari, 1991), and the polecat *Mustela putorius* (Weber, 1987).

Predators that hunt aquatic prey are less tied to the activity of the prey because, being confined to an aquatic environment, prey availability is more constant over 24 hours (Melquist & Hornocker, 1983). However, Bider (1962) suggests that predators that hunt by means of sight and sound require a greater degree of synchrony with their prey. In the following account particular importance is given to relationships between activity patterns and diet.

6.2 MATERIALS AND METHODS

Analysis of activity rhythms was based on radio-tracking data. Procedures of data collection are described in chapter five. Percentage of time spent in activity and in resting during the 24-hour periods was calculated.

Differences in activity over 24 hours were calculated by subdividing the 24 hours into eight three-hour intervals. This smoothes the activity pattern and better identifies peaks of activity and inactivity. Percentage of time spent in activity and in resting was calculated for each time interval. Percentages of activity during the 24 hours (diel activity), and activity rhythms for males and females were also calculated.

Since Kamberg Nature Reserve comprises two areas that differ in terms of habitat, and food resource concentration and availability, a comparison of the activity rhythms in the two areas was conducted.

Percentages of activity during 24h periods and activity rhythms were calculated for the wet (October-March) and dry (April-September) seasons respectively. The significance of differences in peaks of activity or inactivity were tested using the Chi-square Test. Contingency tables were used to test for differences between the sexes, between the Stillerust and the Hatchery areas, and between the wet and dry seasons.

To better understand predatory behaviour and hunting success of the spotted-necked otter, from the 24 hour continuous tracking sessions, mean monthly time spent consecutively in activity was calculated. Data were then pooled according to the four seasons: winter (July, August and September), spring (October, November and December), summer (January, February and March), and autumn (April, May and June). Based on the assumption that consecutive periods of activity are dependent on hunting success, mean monthly time spent consecutively in activity was correlated with the monthly presence of the main food items occurring in the spotted-necked otter's diet. Data concerning the diet were available from a previous study of its feeding ecology in Kamberg Nature Reserve (Carugati, in prep). Pearson's Correlation Index was used to test for significant correlations.

6.3 RESULTS

Data analysis was conducted on 1680 independent observations (defined in chapter 5).

6.3.1 ACTIVITY RHYTHMS: OVERALL ANALYSIS

Spotted-necked otters spent 42% of the 24 hours in activity and 58% resting. No significant differences between males (activity=41%; resting=59%) and females (activity=41%; resting=59%) were found in the time spent in activity in the 24 hours (Chi-square=0.057). Similarly, there were no significant differences in activity phasing between the Hatchery area and the Stillerust area (Hatchery area: activity=42%; resting=58%; Stillerust area: activity=42%; resting=58%; Chi-square=0.007). Contingency tables are reported in Appendix 2, Tables 1 and 2.

Peaks of activity were observed between 06h00 and 09h00 (Chi-square=6,4; p<0,05), between 15h00 and 18h00 (Chi-square=22,9; p<0,001), and between 18h00 and 21h00 (Chi-square=13,3; p<0,001). Peaks of inactivity were detected during the following time intervals: 24h00-03h00 (Chi-square=92,56; p<0,001), 03h00-06h00 (Chi-square=17; p<0,001), 09h00-12h00 (Chi-square=23,6; p<0,001), and 12h00-15h00 (Chi-square=63,2; p<0,001) (Figure 6.1).

No significant differences between males and females (Chi-square=16,8) in activity over 24 hours were detected (Figure 6.2), or between the Hatchery and the Stillerust areas (Chi-square=17,1) (Figure 6.3). Contingency Tables are reported in Appendix 2, Tables 4 and 5.

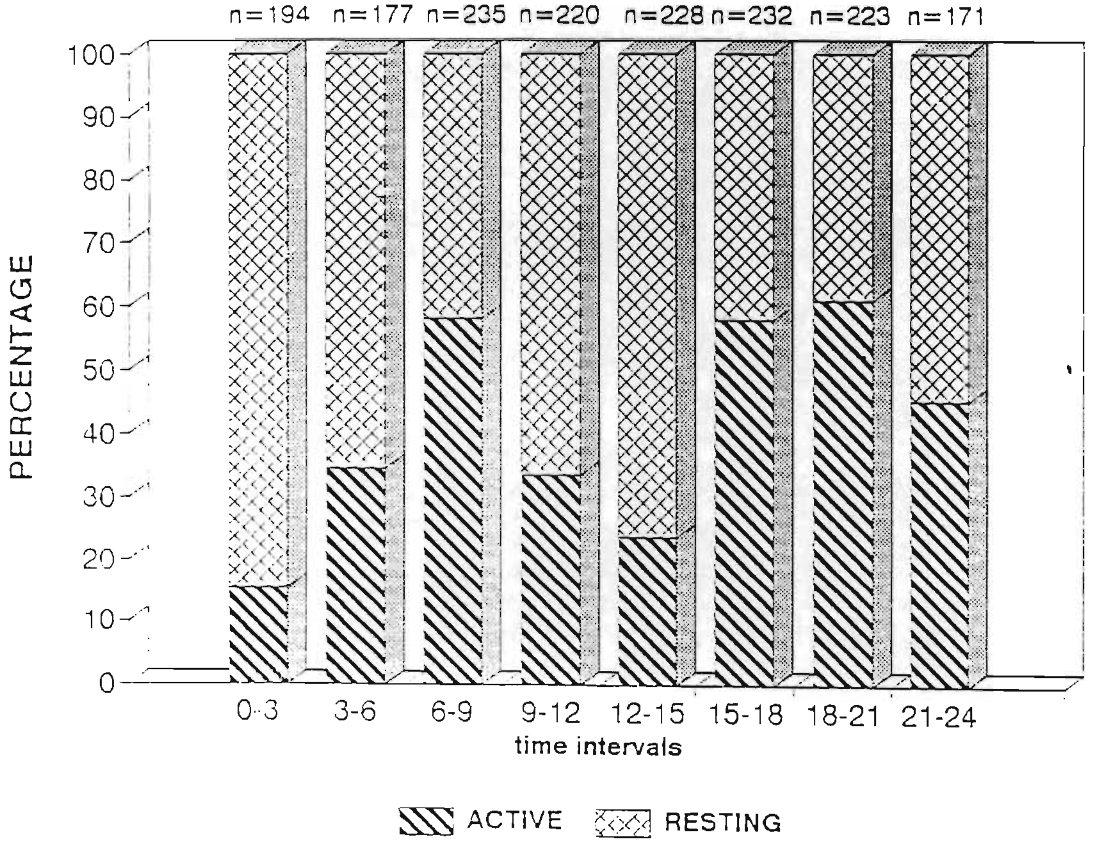


Figure 6.1 Activity of spotted-necked otters at three-hour by intervals: overall analysis (N=1680).

A significantly higher level of nocturnal activity (Chi-square=9,6; p<0,01) was recorded when the moon was present (Figure 6.4). A contingency table is provided in Appendix 2, Table 6.

6.3.2 ACTIVITY RHYTHMS: SEASONAL ANALYSIS

During the wet season, animals spent 43% of the 24 hour period active and 57% resting; during the dry season, animals were found to be active or resting for 42% and 58% of the 24 hours respectively. No significant seasonal differences in the percentage of time spent in activity and in resting during the 24 hours were detected (Chi-square=0,186).
A contingency table is reported in Appendix 2, Table 7.

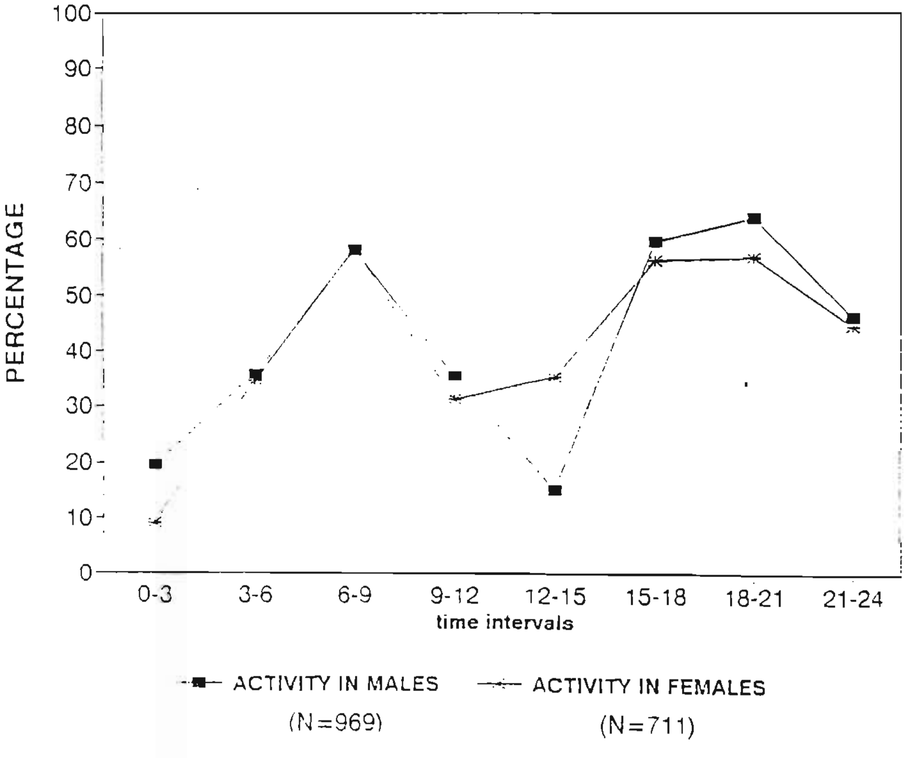


Figure 6.2 Activity at three-hour by intervals: a comparison between males and females.

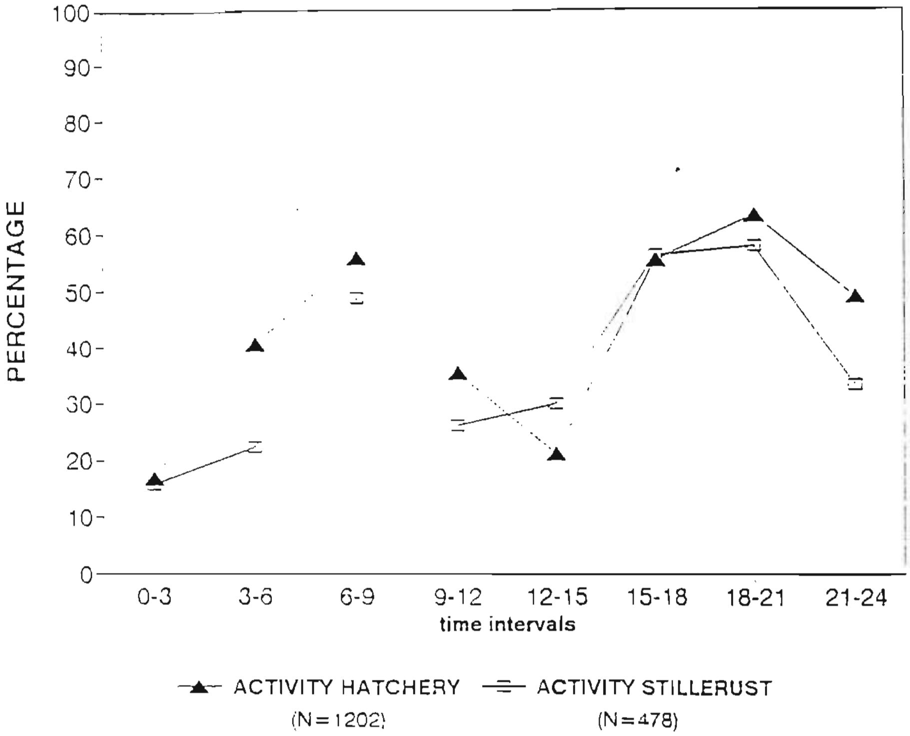


Figure 6.3 Activity at three-hour by intervals: a comparison between the Hatchery and Stillerust areas.

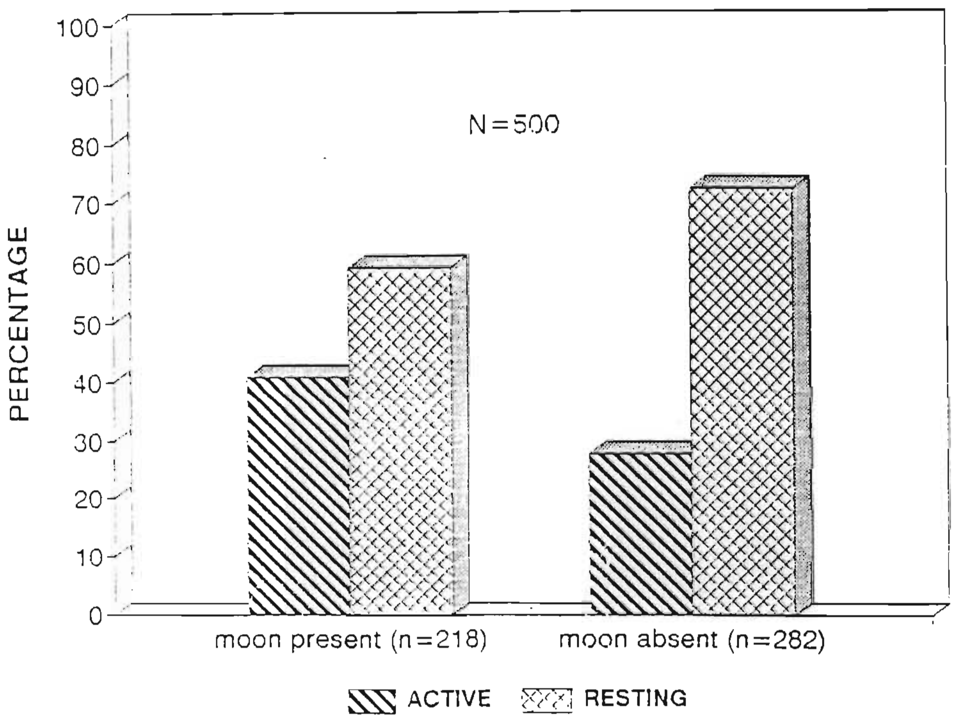


Figure 6.4 Variation in the nocturnal activity of spotted-necked otters in relation to the presence of the moon.

Significant differences were found when activity during 24h periods during the wet and dry season were compared (Chi-square=31,03, p<0,001) (Figure 6.5). Differences were mainly due to variation in times of sunset and sunrise. A contingency table is provided in Appendix 2, Table 7.

6.3.3 USE OF TIME IN RELATION TO FOOD RESOURCE EXPLOITATION

Seasonal variations were shown in the mean time spent in consecutive activity. During the dry season (autumn and winter) otters were active consecutively for a longer time (68

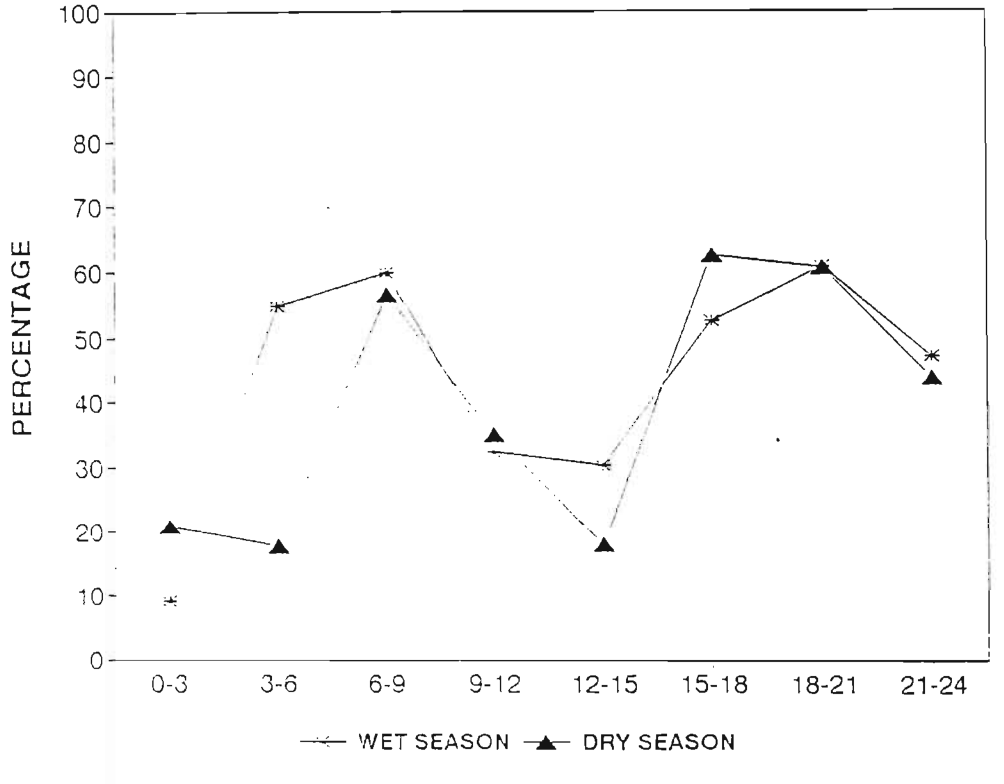


Figure 6.5 Activity at three-hour by intervals: a comparison between wet and dry seasons.

minutes and 70 minutes respectively) than in wet season (spring and summer), where the mean times recorded were 34 minutes and 53 minutes respectively.

Seasonal variations were also found in the spotted-necked otter's diet. In autumn and winter, fish was the main prey category (frequency of occurrence: 59% and 54% respectively), while in spring and summer it constituted only 19% and 7% respectively of the diet (Carugati, in prep.). The other main prey items eaten by the spotted-necked otter (crabs, frogs and insects) were eaten mainly in spring (77%) and summer (46%). In autumn and winter the otters fed on the above three items less often: 45% and 39% respectively. A significant positive correlation was found between seasonal mean time spent by the otters in consecutive activity and the presence of fish in the diet ($r=0.708$; $p<0.05$) (Figure 6.6); however, a significant inverse correlation was found between the seasonal mean time of consecutive activity and the presence of the other food items in the diet ($r=-0.912$; $p<0.001$) (Figure 6.7).

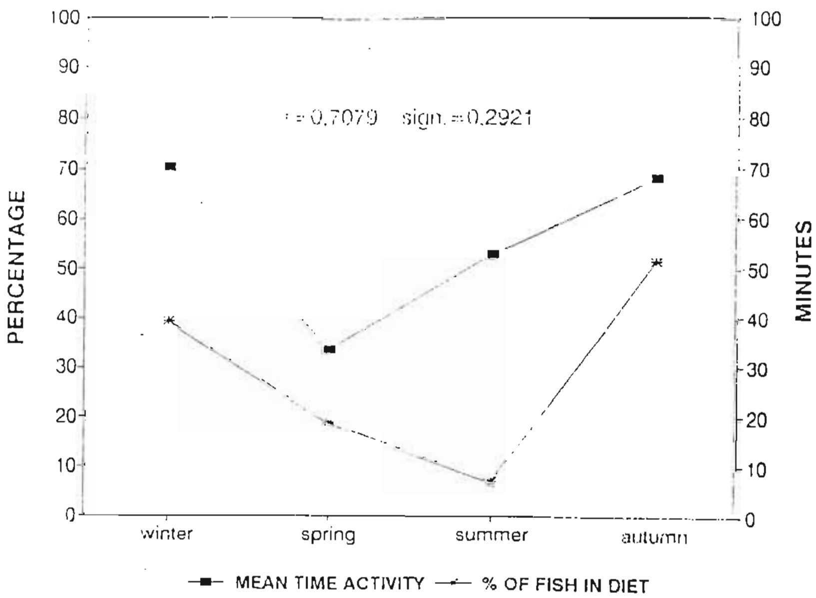


Figure 6.6 Seasonal variations in the percentage of fish in the spotted-necked otter's diet and average mean time spent in consecutive activity.

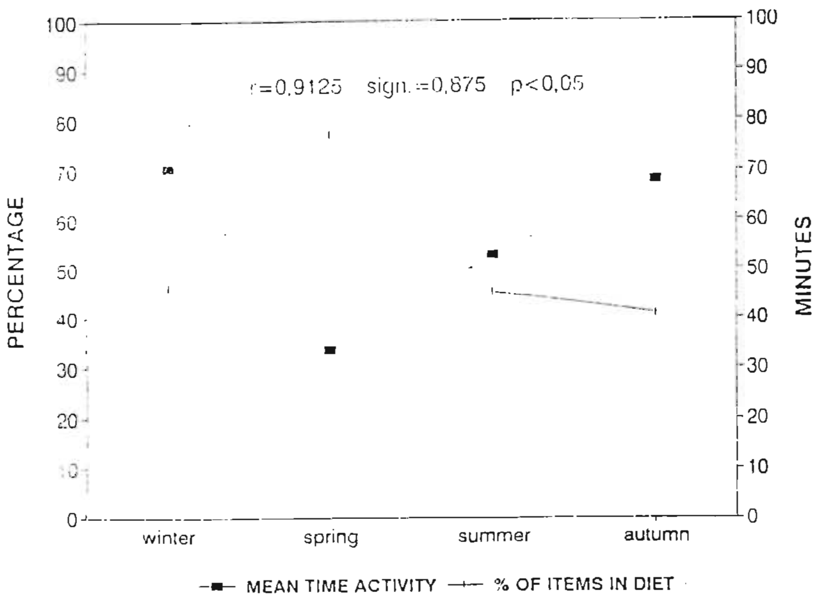


Figure 6.7 Seasonal variations in the percentage of non-fish items (crab, frog, insect) in the spotted-necked otter's diet and average mean time spent in consecutive activity.

6.4 DISCUSSION

Synchronisation between predators and prey has been found in many terrestrial carnivores while it has never been detected in carnivores preying on aquatic species. Melquist & Hornocker (1983) assumed that, being confined to an aquatic environment, aquatic prey availability does not vary during the day, and therefore does not affect the activity of animals feeding on them. However, Bider (1962) hypothised that predators that hunt by means of sight, as otters do, and sound, require a high degree of temporal synchronisation with their prey. Among the main food items exploited by spotted-necked otters, trout are active at similar times to spotted-necked otters. Trout show peaks of activity in the early morning and late afternoon, while activity at midday is generally associated with low temperatures. Moonlight seems to affect trout activity, keeping them on the move during the night (Crass, 1986). Less information regarding activity rhythms of the three indigenous fish species occurring in the area (scaly fish, chubbyhead barb and mountain catfish) is available, but they are commonly considered as being diurnal. Available literature regarding the activity rhythms of crabs and frogs is very poor, but both are commonly recognized to be active throughout the day. The decrease of crabs and frogs in the otter's diet during winter (Carugati, in prep.; Rowe-Rowe, 1977a) suggests that active animals are actually more easily hunted. In cold water a fish's swimming ability is reduced and it is more easily captured (Rowe-Rowe, 1977b). This is also confirmed by the study of predatory behaviour of the spotted-necked otter conducted in captivity by Rowe-Rowe (1977b), who observed that the spotted-necked otter's hunting techniques consist of locating prey animals by sight and chasing them. Both crabs and frogs hibernate in winter, becoming less visible and consequently less available as a food resource.

The tendency to be active predominantly in daylight is because spotted-necked otters hunt by sight (Chanin, 1985; Rowe-Rowe, 1977b). That tendency was underlined by significantly higher nocturnal activity during moonlight. A certain degree of synchrony with prey could be hypothesised only in the case of fish, particularly trout. Similarity in activity phasing is partially explained by the fact that both spotted-necked otters and trout are predators hunting by sight, and are therefore active when visibility is good. Seasonal differences in the activity rhythms were probably due to the change in times of sunset and sunrise.

Seasonal foraging patterns reflect a correlation between activity of the prey and hunting success of the otters. The time that spotted-necked otters are consecutively active varies seasonally, together with the abundance of fish and non-fish (frogs, crabs and insects) prey in the diet. Assuming that the length of a foraging period is determined by hunting success, the higher average time spent consecutively active by the otters when feeding mainly on fish is explained, owing to the greater hunting effort required to catch such prey. Since hunting by spotted-necked otters is based on locating and chasing the prey, the ability of the prey to escape determines the hunting success. Fish, and especially trout (Crass, 1986), are likely faster and stronger swimmers than the other prey items mentioned above, requiring a greater hunting effort (Rowe-Rowe, 1977b).

Examining the reasons for the apparent decline of spotted-necked otters in Lake Victoria, Kruuk & Goudswaard (1990) hypothesised that the introduction of the alien Nile perch *Lates niloticus* and the consequent decline or even extinction of many indigenous fish species could have caused a decline in food availability, since Nile perch is a much larger and are stronger swimmer than the small indigenuous species which the spotted-necked otters feed on. Rowe-Rowe (1977c) found that the Cape clawless otter was much more efficient in hunting indigenous fish species than hunting trout. Therefore it is not surprising that a piscivorous species such as the spotted-necked otter is more efficient in hunting preys that, in an optimal situation, would be a marginal component of their diet.

Analysis of the activity rhythms leads to the following conclusions:

- Spotted-necked otters are mainly active when their efficiency of detecting prey by sight is high, that is during daylight and moonlight
- Temporal synchrony with prey is doubtful, and limited only to trout
- Hunting success varied in relation to the food resource exploited

CHAPTER 7 USE OF SPACE AND INTRASPECIFIC RELATIONSHIPS

7.1 INTRODUCTION

Home range was first defined by Burt (1943) as that area traversed by an individual in its normal activities of food-gathering, mating and caring for young. Various methods have been used to estimate the home range of animals. One of the first home range estimation methods was the Minimum Convex Polygon (MCP) (Hayne, 1949), where the peripheral locations of an animal's position are connected in such a way that the internal angles of the polygon thus generated do not exceed 180 degrees. This method gives a fair indication of the area used by an animal, but is strongly affected by sample size and does not give any indication of the intensity of use of the area included in the polygon. The probabilistic methods of home range analysis attempt to assess an animal's probability of occurrence at each point in space, or its use distribution (Van Winkle, 1975). Some of these methods, including the Weighted Bivariate Normal Ellipse (Samuel & Garton, 1985) and the Multiple Ellipse (Don & Rennols, 1983) assume that an individual's pattern of space use conforms to a particular probability distribution, for example a bivariate or circular normal. Other methods, such as the Harmonic Mean (Dixon & Chapman, 1980) and the Kernel Method (Worton, 1989) do not have restrictions regarding the shape of an individual's home range and give a representation of the internal use of an animal's home range.

An important concept in describing the internal anatomy of home ranges is the 'core area', first defined by Kaufmann (1962), to denote central areas of consistent intense use that probably contain home sites, refuges, and the most dependable food resources. The concept of 'core area' is not only important in defining the internal structure of an individual's home range, but also in studying the interactions between individuals, since it is not uncommon to find that while home ranges overlap, core areas do not (Ewer, 1968).

Interactions between individuals can be measured using two different approaches: static territorial interaction and dynamic territorial interaction (Dunn & Gipson, 1977; MacDonald, Ball, & Hough, 1980) . The first approach consists of measuring the percentage of overlap between two individuals' home ranges. A static interaction does not imply any mutual awareness among the respective animals, and is influenced by the accuracy of the home range estimations. The dynamic territorial interaction measures the way in which movements of two animals with overlapping home ranges are related, and enables one to determine whether individuals with overlapping home ranges avoid or attract each other.

Spotted-necked otters are commonly considered social, being mainly observed in groups (Kruuk & Goudswaard, 1990; Procter, 1963; Rowe-Rowe, 1978). The influence of resource dispersion and abundance on the behaviour and social organization has been shown for many carnivore species (e.g.: Bekoff, Daniels & Gittleman, 1984; Kruuk, 1978; Kruuk & Macdonald, 1985; Macdonald, 1983; Mills, 1989). Here it is hypothesised that different social behaviours occur in the Hatchery area, where food resources are abundant and concentrated, and in the Stillerust area, where food resources are dispersed and vary seasonally in abundance.

7.2 MATERIALS AND METHODS

Analysis of the use of space and intraspecific relationships studied here is based on radio-tracking data. Procedures of data collection were described in chapter five. Home ranges of each radio-tracked animal were estimated using both the Minimum Convex Polygon (MCP) (Burt, 1943) and the Harmonic Mean (Dixon & Chapman, 1980) methods, by means of the computer package Home Range (Ackerman, Leban, Samuel & Garton, 1990). The MCP method, as discussed in paragraph 7.1, is defined by connecting the peripheral locations of an animal in such a way that the internal angles of the polygon generated do not exceed 180 degrees. This method does not give any indication of how the area comprised by the polygon is used by the animal, is strongly affected by peripheral fixes, and the range area can include large areas that are never or seldom visited, but it is very useful in comparing home ranges of two or more animals or separate data sets. In order to reduce the effect of outliers and to provide more information on core areas used within the home range, 'percent convex polygons' (Michener, 1979; Bowen, 1982; Bekoff & Mech,

1984) were calculated. For each individual, MCP including 100%, 95%, and 75% of the observations were calculated.

The Harmonic Mean method estimates home ranges by determining a distribution of use. The determination of a use distribution requires estimating the probability of use at any location in the home range. The contours of use distribution may be chosen as specified percentages of the animal's use distribution. The centres of activity are located in the areas of greatest activity, and the activity area isopleths are related directly to the frequency of occurrence of an individual within its home range. For each individual, Harmonic Mean area was calculated with contours set at 95% and 75% of the use distribution.

Core areas were calculated by means of the computer programme Home Range, as the maximum area where the observed use distribution, based on harmonic values, exceeded a uniform use distribution. Core areas are in fact identified by that computer package by comparing the use distribution from harmonic mean calculations with a uniform use model (Samuel & Garton, 1985).

Since animal M1 was radio-tracked for only three months, data concerning his home range estimation were not considered complete, and therefore were not included in the analyses described below. The female F3 spent the first month after being radio-tagged in the Stillerust area, moving to the Hatchery area, where she stayed constantly without going back to Stillerust by the time the radio implant battery was exhausted (after 11 months). Her home range was calculated, first, by using the whole sample, and second, by excluding the observations recorded during the first month of radio-tracking. In the analyses described below, the latter mentioned home range is included.

Average 100% and 95% MCP home range areas and average home range area estimates generated by the Harmonic Mean method with a contour set at 95% were calculated, as was the average dimension of the core areas. Chi-square tests were used to detect differences in home range size among individuals of the same sex, using both the 100% MCP and the home ranges estimated with the Harmonic Mean method with a contour at 95%. Differences were considered significant when $p<0.05$. Wilcoxon Mann-Whitney U test was used in order to detect differences in the home range sizes between the two sexes.

To investigate the influence of food resource abundance and dispersion on home range size, only females were considered. The spatial organization of males is strongly influenced by the distribution of females, while female spacing patterns are mainly determined by the dispersion and abundance of food (Erlinge & Sandell, 1986; Sandell, 1989). Home ranges of radio-tracked males included both the Hatchery and the Stillerust areas, while, among the females, F3, with the exception of the first month of radio-tracking, was resident in the Hatchery area; F2 and F6 were both resident in the Stillerust area. Differences in the home range areas at the Hatchery and in the Stillerust area were therefore deducted from the differences detected in home range size among females.

Intraspecific relationships were investigated considering the dynamic territorial interaction. Home ranges of males were in fact almost identical in area and completely overlapped, as well as the ones of the two females F2 and F6; the home range of the female F3 was completely included within those of the males. Animals did not show any intersexual or intrasexual territorial behaviour, and consequently the static territorial interaction could not give any additional useful information regarding individual interactions. Overall percentage of time a single animal, two animals, or a group of three or more individuals, were seen together was calculated using exclusively visual observations of both radio-marked and non radio-marked spotted-necked otters.

Cole's (1949) coefficient of association was used in order to investigate whether animals with overlapping home ranges were actively interacting or avoiding each other. The coefficient (CA) equals:

$$CA = \frac{2AB}{A+B}$$

where A is the number of times animal 1 was observed during a specific period, B is the number of times animal 2 was observed during the same period, and AB is the number of times animals 1 and 2 were observed together throughout the entire period. The coefficient CA varies between 1 (where A and B are always observed together) and 0 (where A and B are never observed together).

Changes in foraging patterns and in social behaviour in relation to food resource abundance and dispersion have been found in many carnivore species (e.g.: Bekoff, Daniels & Gittleman, 1984; Kruuk, 1978; Kruuk & Macdonald, 1985; Macdonald, 1983; Mills, 1989; Schaller, 1972). The influence of food resource abundance and dispersion on social behaviour was tested here, based on the hypothesis that where food is abundant and concentrated, foraging at the same time in the same place is more efficient than if resources are less abundant and more dispersed. This hypothesis was tested in two different ways. The number of visual observations in which a single animal, two animals, or a group of three or more animals were seen together at the Hatchery or in the Stillerust area were compared, and differences were tested by a contingency table and considered significant when $p<0,05$.
Values obtained with the Cole's coefficient of association were compared by means of the Student's t test to detect whether avoidance among individuals with overlapping home ranges was higher at Stillerust than in the Hatchery area.

7.3 RESULTS

7.3.1 USE OF SPACE

The average home range size of spotted-necked otters, estimated with the MCP method including 100% of the observations, was 11,3 km^2, while the average of the 95% MCP was 5,9 km^2. Values obtained using the Harmonic Mean method were much higher, with average home range areas with contours at 95%, of 27,4 km^2. The average home range size estimated whit the Harmonic mean including 75% of the observations was 8.41 km^2. The average size of core areas was 6,0 km^2, whereas the average length of the Mooi River included in the home ranges was 14.8 km. Values obtained for each individual are illustrated in Table 7.1.

No significant differences were found in male home range areas (MCP:chi-square=0.16; Hmean:chi-square=0,09), while significant differences were found among females (MCP:chi-square=5,95, $p<0,05$; Hmean:chi-square=8,90, $p<0,05$).

Table 7.1 Home range dimensions of the radio-tracked spotted-necked otters (area expressed in km², lengths in km). The sample size (n) indicates the number of observations used for each animal.

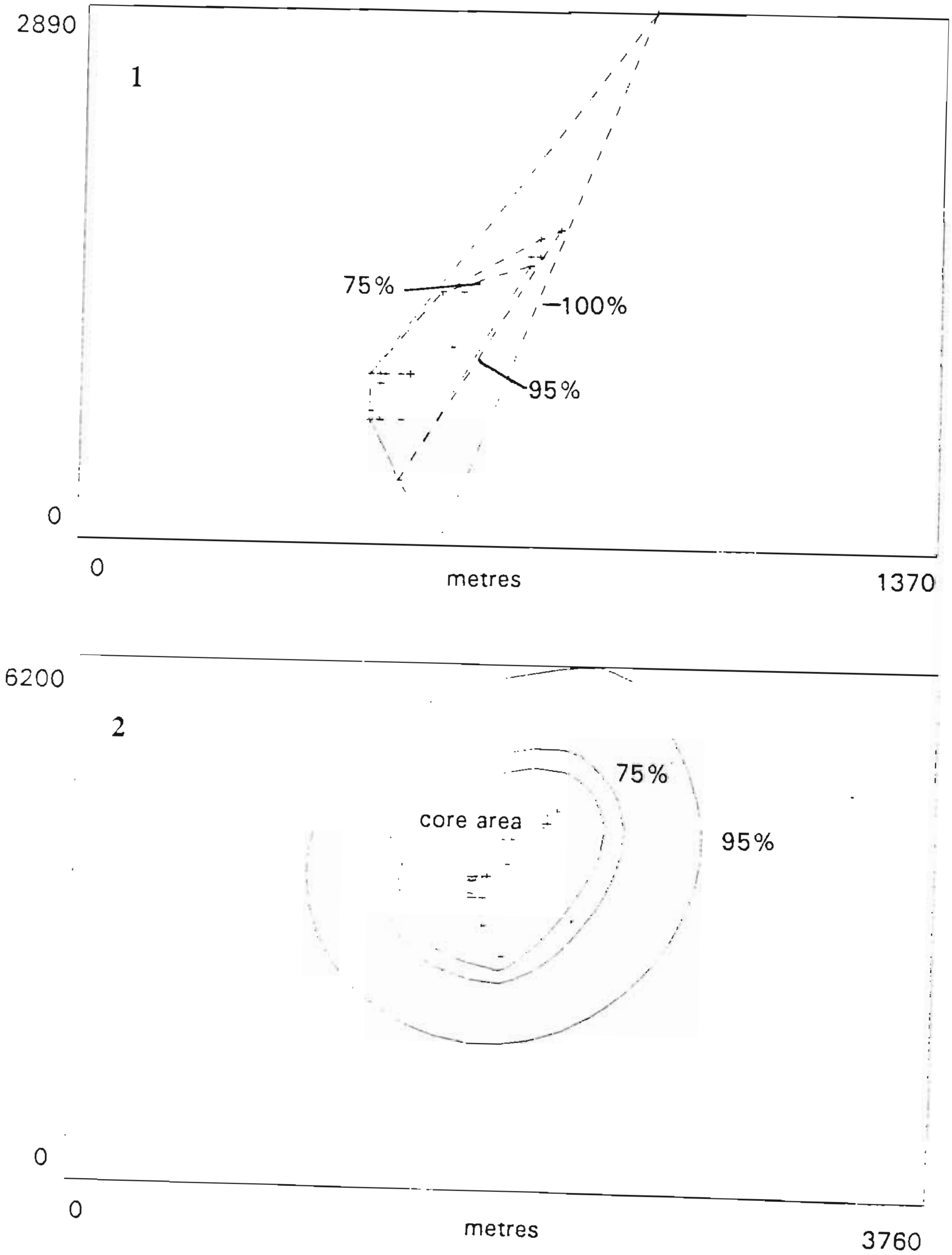
OTTER	n	LOCALITY	MCP 100% (skm)	MCP 95% (skm)	HMEAN 95% (skm)	HMEAN 75% (skm)	CORE AREA (skm)	INCLUDED (MCP100%)
Males								
M4	259	Hatchery+Stillerust	17,14	9,20	45,07	11,26	7,55	24,10
M5	283	Hatchery+Stillerust	16,82	5,76	43,85	12,56	9,41	23,20
M7	212	Hatchery+Stillerust	14,87	2,87	42,18	12,83	9,09	22,40
Mean			***16,28***	***5,94***	***43,70***	***12,22***	***8,68***	***23,23***
Females								
F2	126	Stillerust	10,06	9,45	14,52	7,04	4,38	10,30
F3	216	Hatchery	1,66	1,14	3,06	1,44	1,00	7,20
F6	111	Stillerust	7,53	6,77	15,98	8,52	4,91	6,90
Mean			***6,42***	***5,79***	***11,19***	***5,67***	***3,43***	***8,13***

It is interesting to underline that this difference reflects a difference in the home range areas between the females resident in the Stillerust area, and the one resident at the Hatchery. The home ranges of the females F2 and F6, resident in the Stillerust area, were similar in size and much larger that of the female F3, resident in the Hatchery area. Intersexual differences in home range areas were also found: males home ranges were significantly larger than those of females (Wilcoxon Mann-Whitney U test: MCP $P(U<=a)=0,05$; Hmean $P(U<=a)=0,05$).

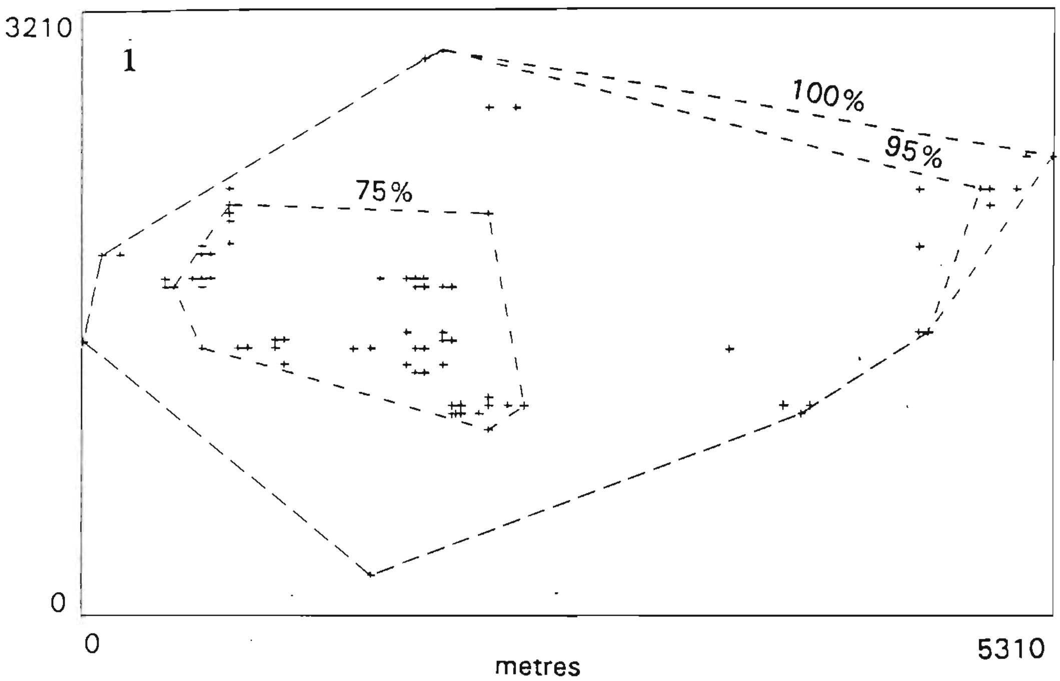
At the Hatchery, core areas of the radio-tracked animals coincided with the dams, whereas at Stillerust core areas included both the river and the oxbow lakes. In both the females F2 and F6, resident in the Stillerust area, a core area was identified at the dams situated at about 1,5 km from the Mooi river, in between the Stillerust area and the farmland, and reached by the animals through a temporary tributary stream. Home ranges of each animal are illustrated in Figure 7.1.

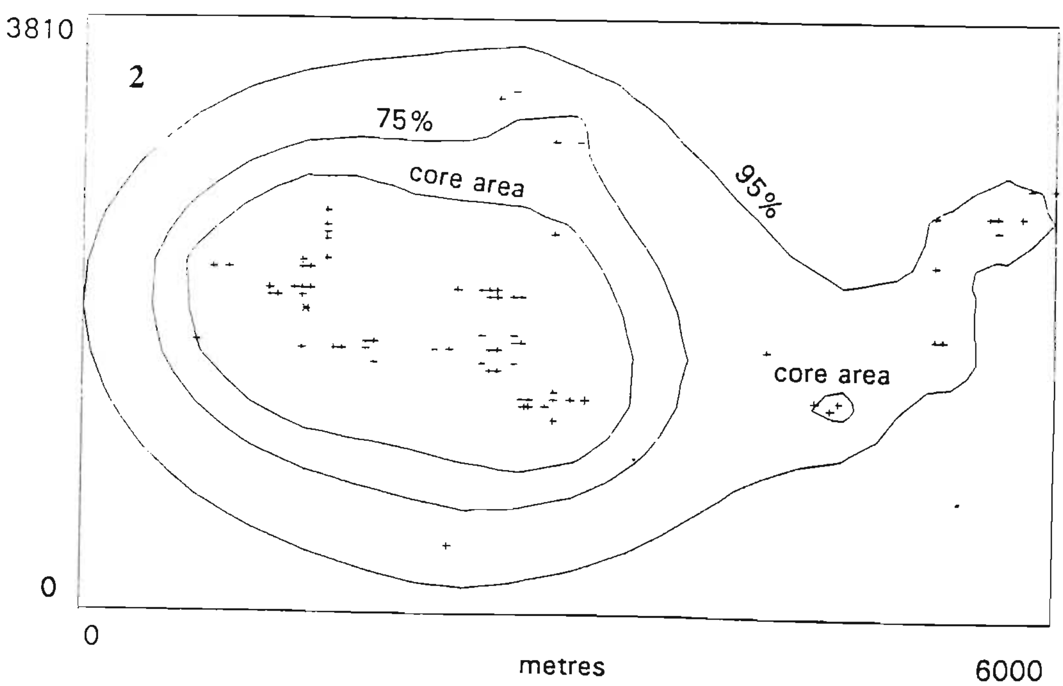
The above data, together with visual observations recorded during the research, enabled me to estimate spotted-necked otter density in Kamberg Nature Reserve. In the Hatchery area a maximum of 11 animals (one group of 6 individuals and another of 5 individuals) were observed simultaneously. In the Stillerust area most of the observations were of solitary animals or two animals together. F2 and F6, both resident in the Stillerust, were rarely observed together (see Table 7.4). However, both of them were observed together with a non radio tagged animal.These observations lead me to suppose that two resident pairs of spotted-necked otters are present at Stillerust. Considering the two areas together, the spotted-necked otters population in Kamberg Nature Reserve amounted to 10-15 animals for about 24 km of river, that equals 1 otter per 1,6 2,4 km of river.

Figure 7.1 Home ranges of the radio-tracked spotted-necked otters (MCP and Harmonic Mean). The x and y axes are expressed in metres. Crosses indicates centres of activity.

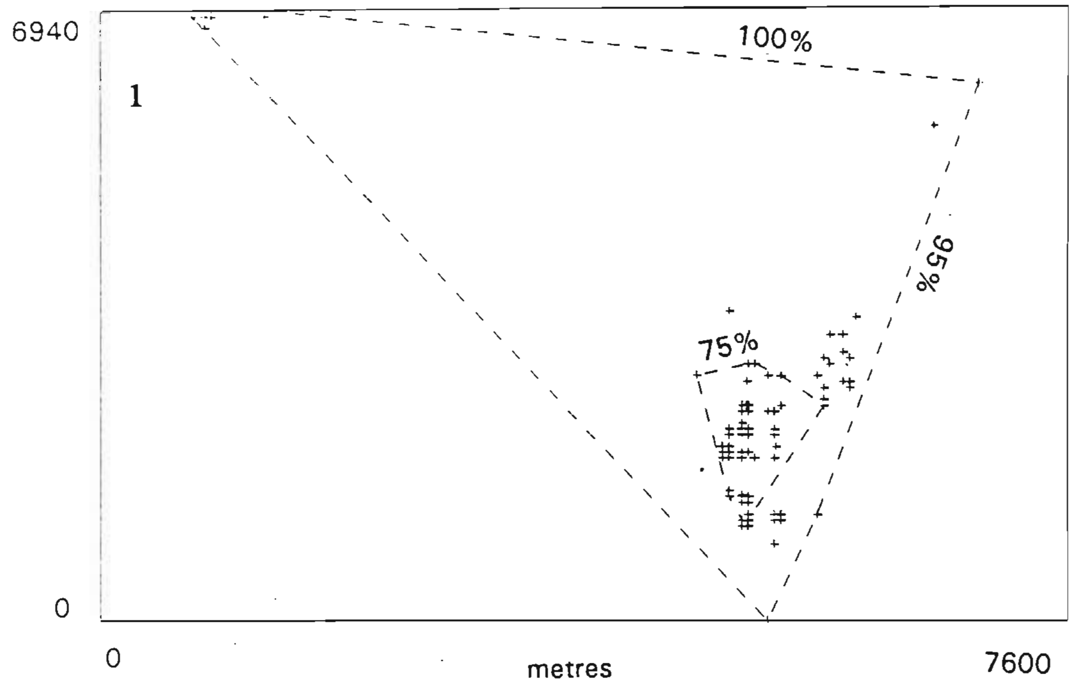


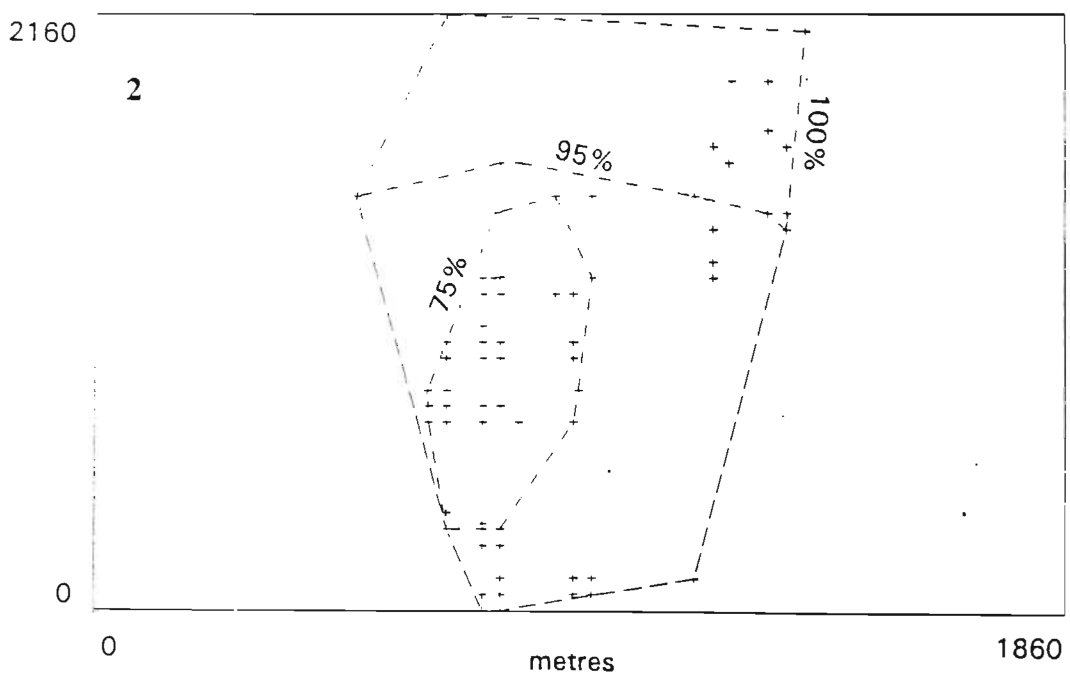
MCP (1) and Hmean (2) of animal M1.



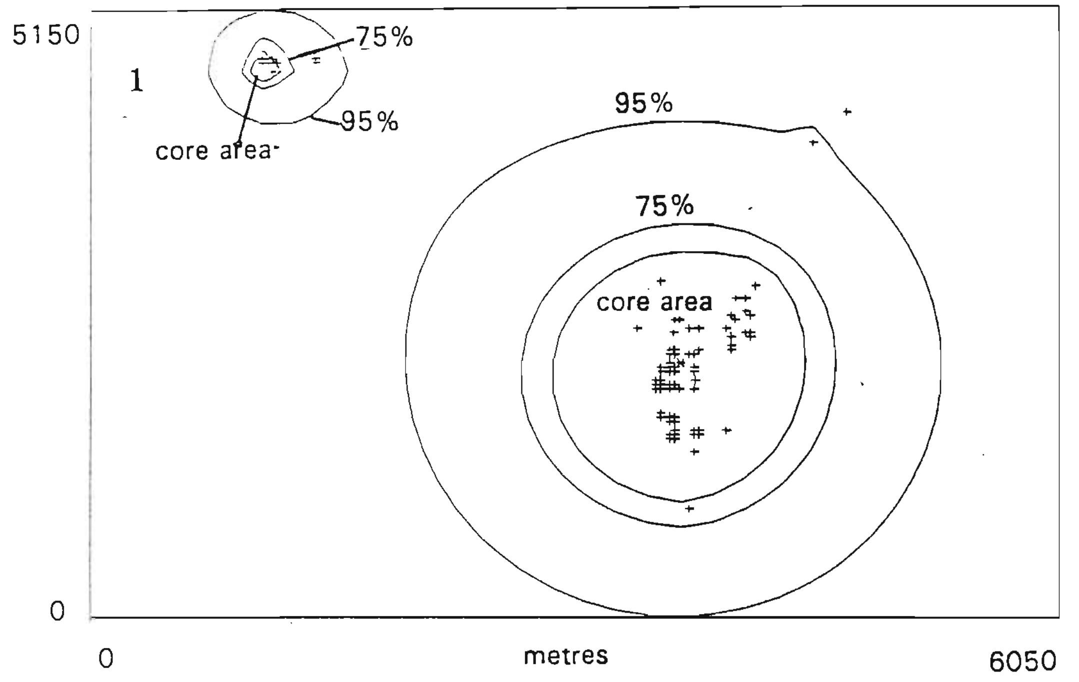


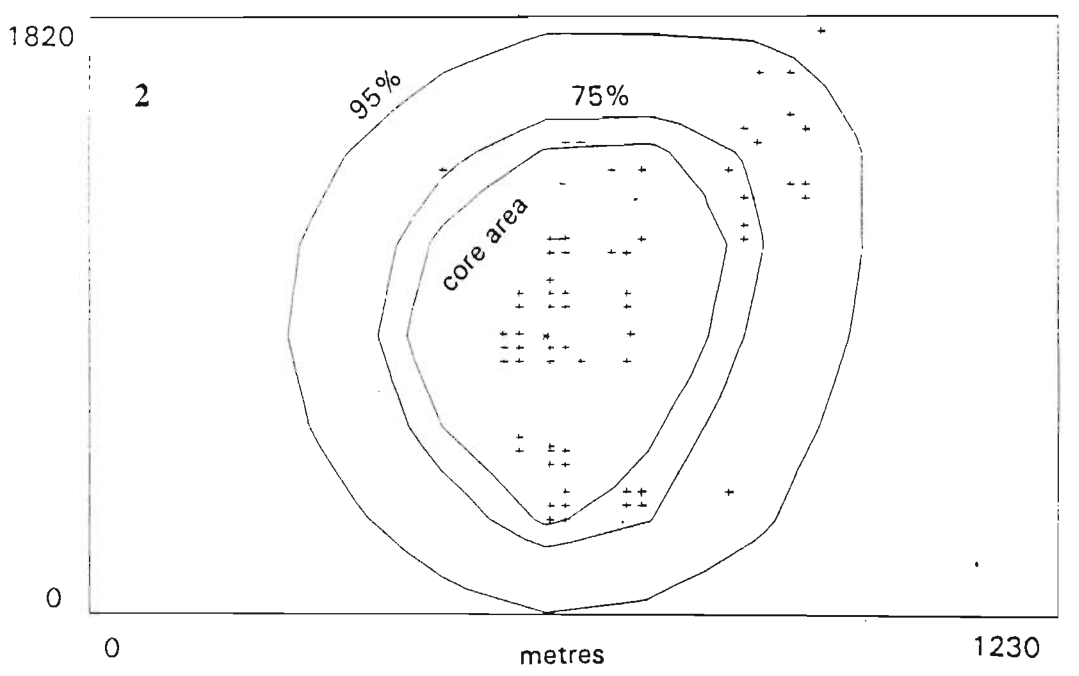
MCP (1) and Hmean (2) of animal F2.



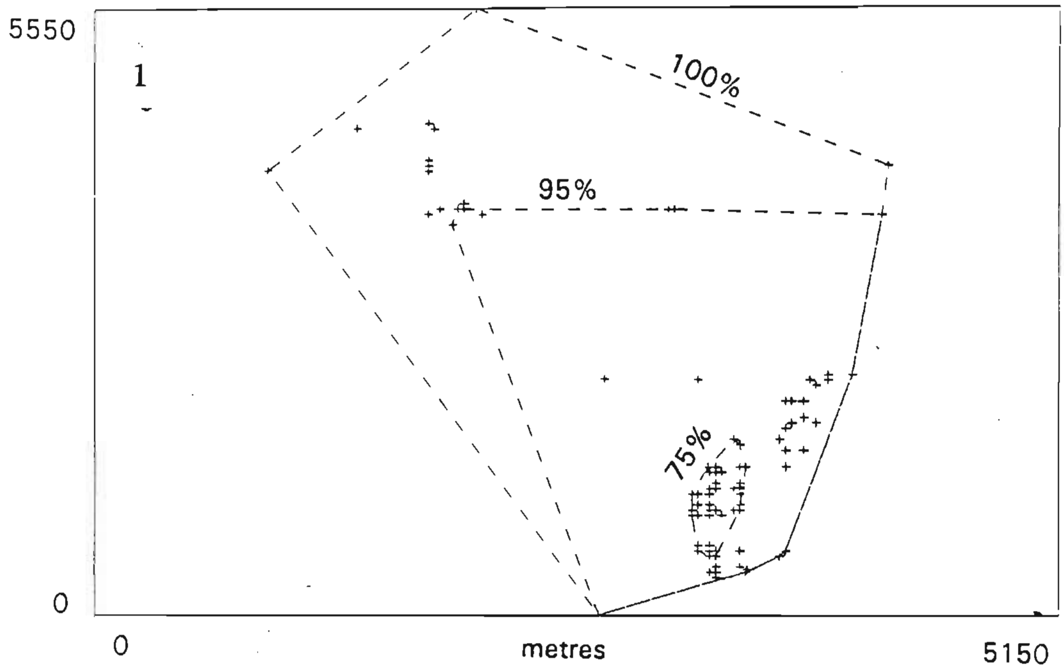


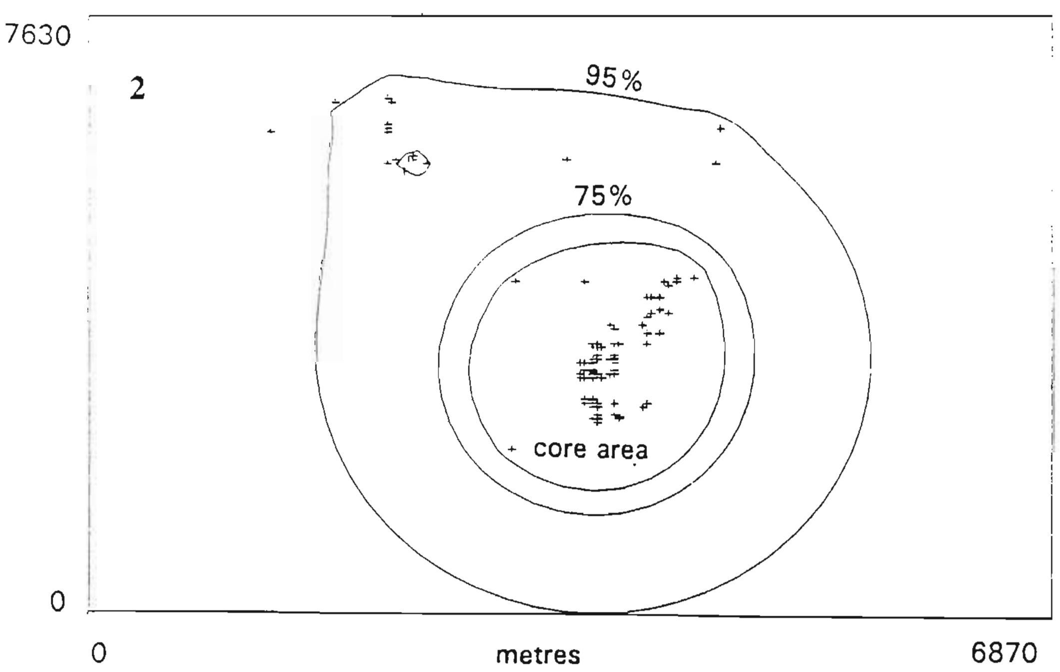
MCP of animal F3 over the whole radio-tracking period (1) and from Aug. '94 to Aug. '95 (2) (Hatchery).



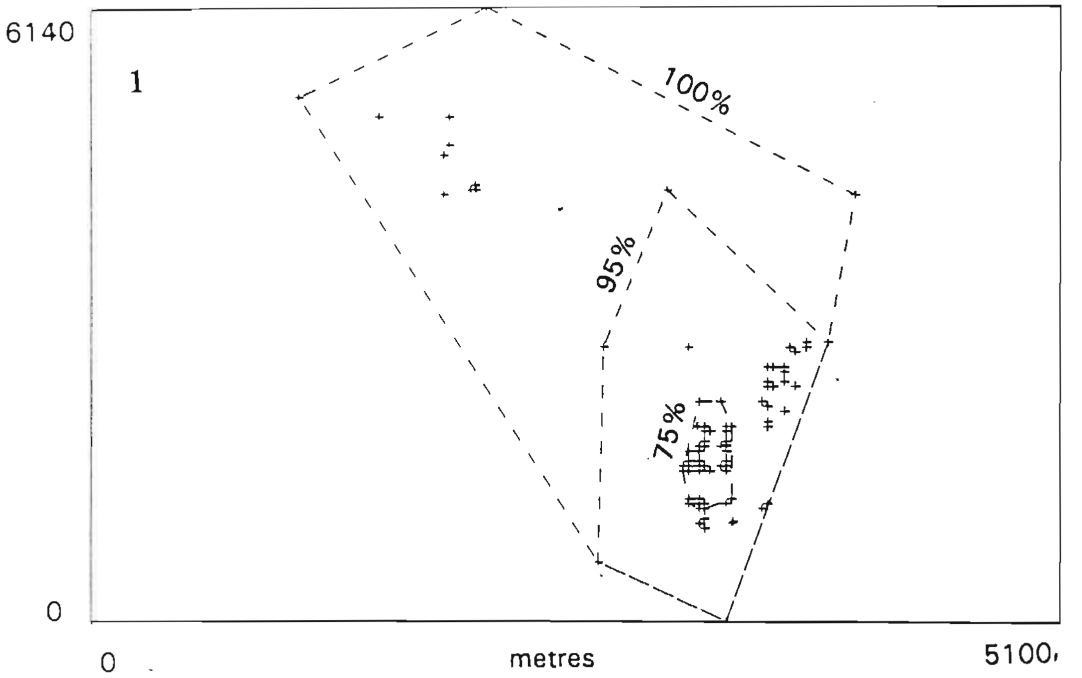


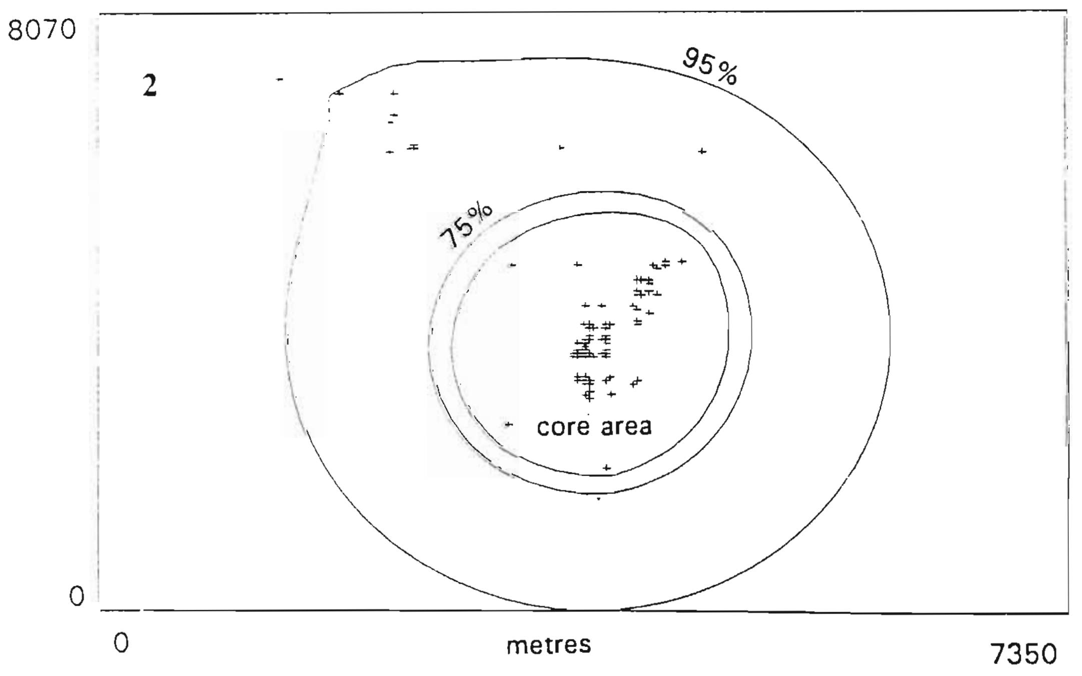
Hmean of animal F3 over the whole radio-tracking period (1) and from Aug. '94 to Aug. '95 (2) (Hatchery).



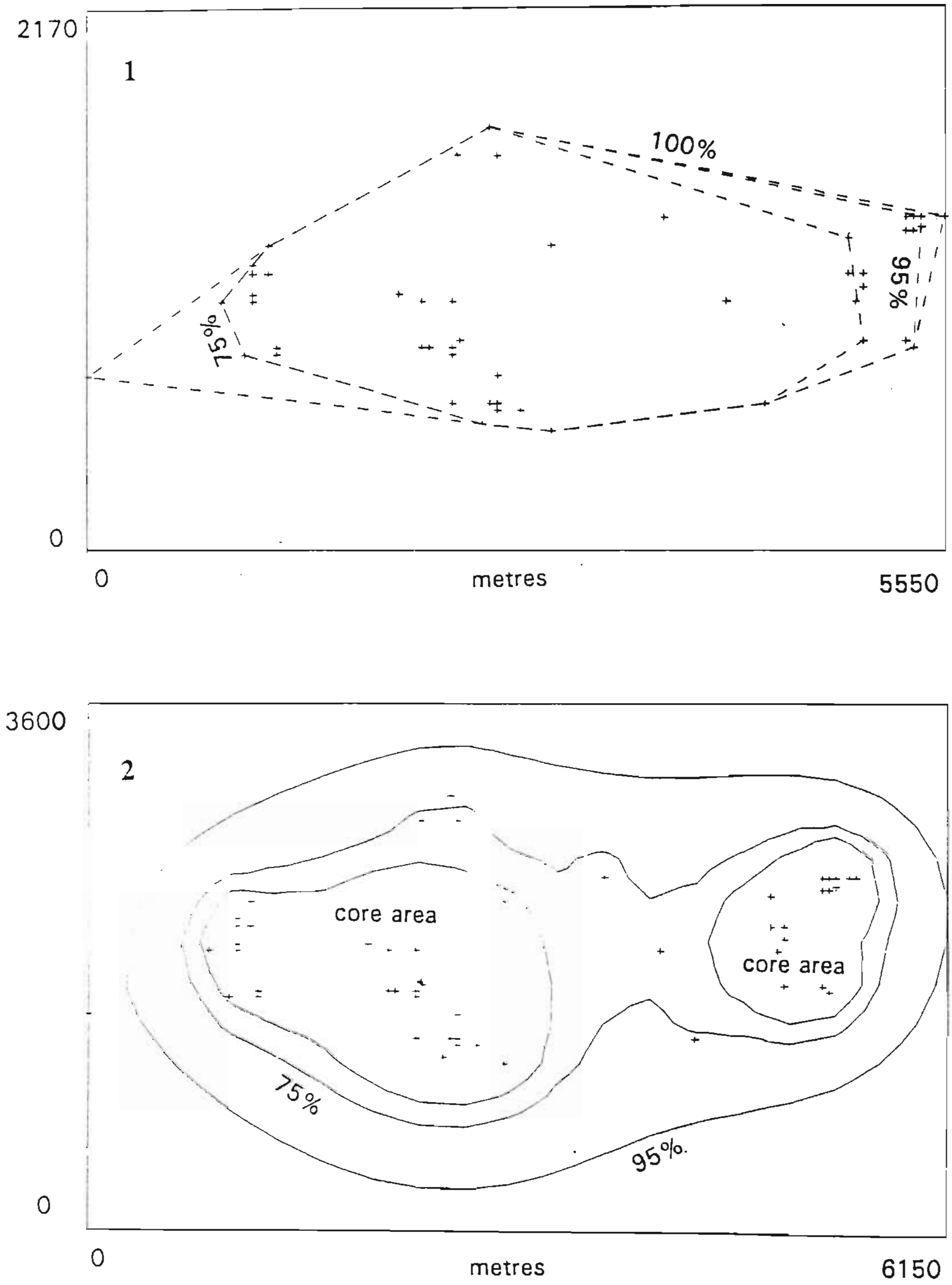


MCP (1) and Hmean (2) of animal M4.

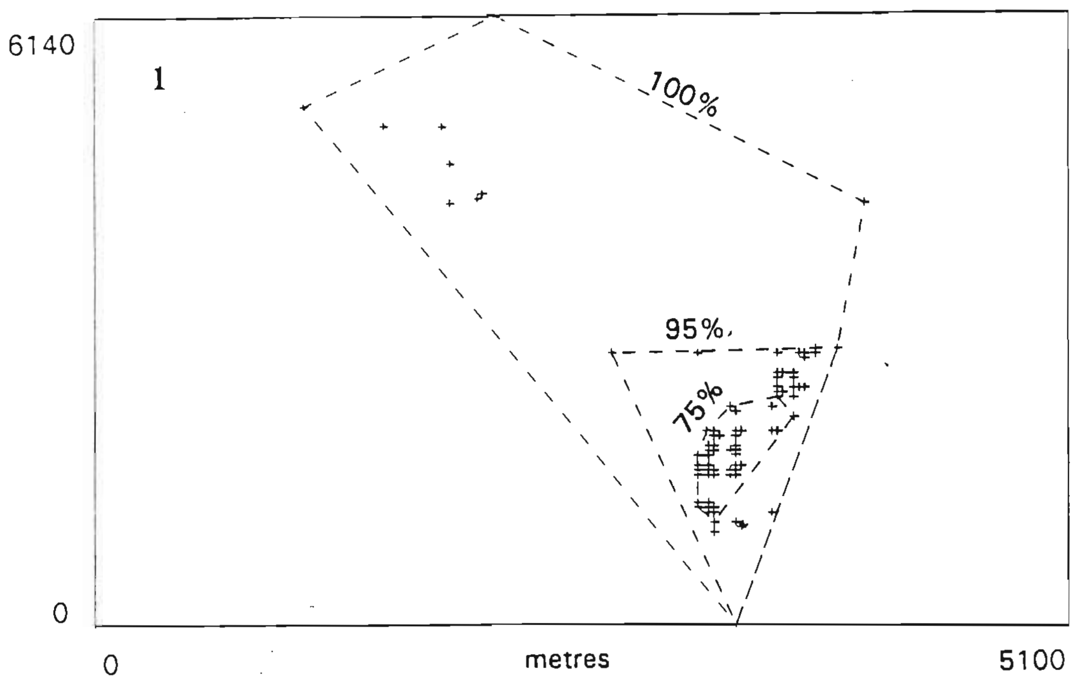


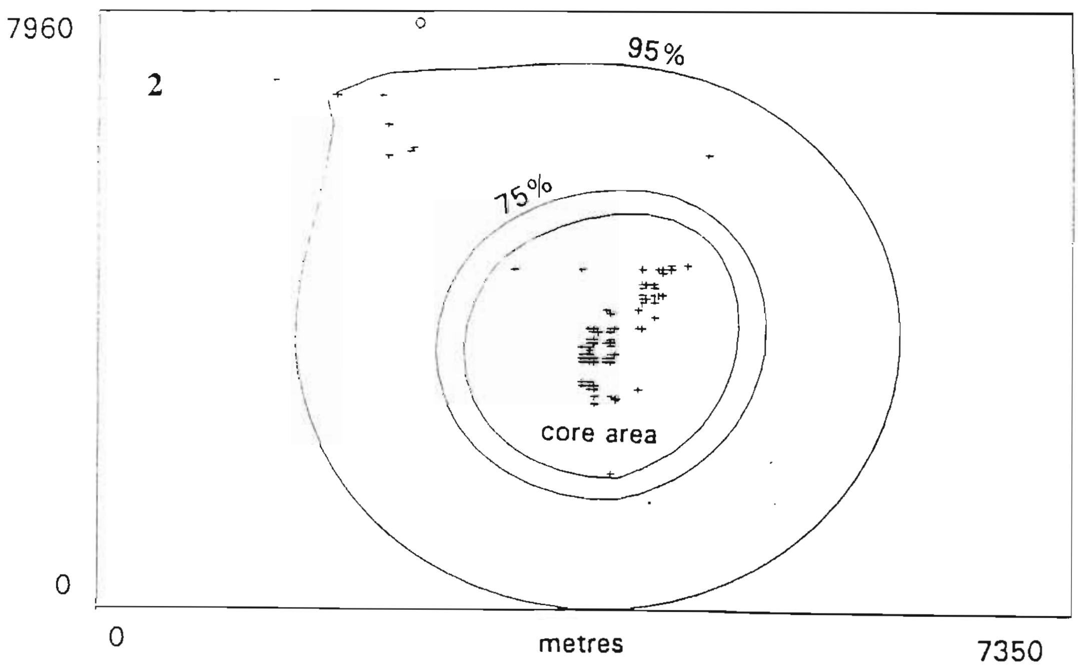


MCP (1) and Hmean (2) of animal M5.



MCP (1) and Hmean (2) of animal F6.





MCP (1) and Hmean (2) of animal M7.

7.3.2 INTRASPECIFIC RELATIONSHIPS

No intrasexual or intersexual territoriality was detected. As shown in Figure 7.2. the home ranges of the three radio-tracked males M4, M5, and M7, and those of the two females F2 and F6, were almost identical in size and completely overlapped. The home range of F3, once stabilized in the Hatchery area, was completely included within those of M4, M5, and M7.

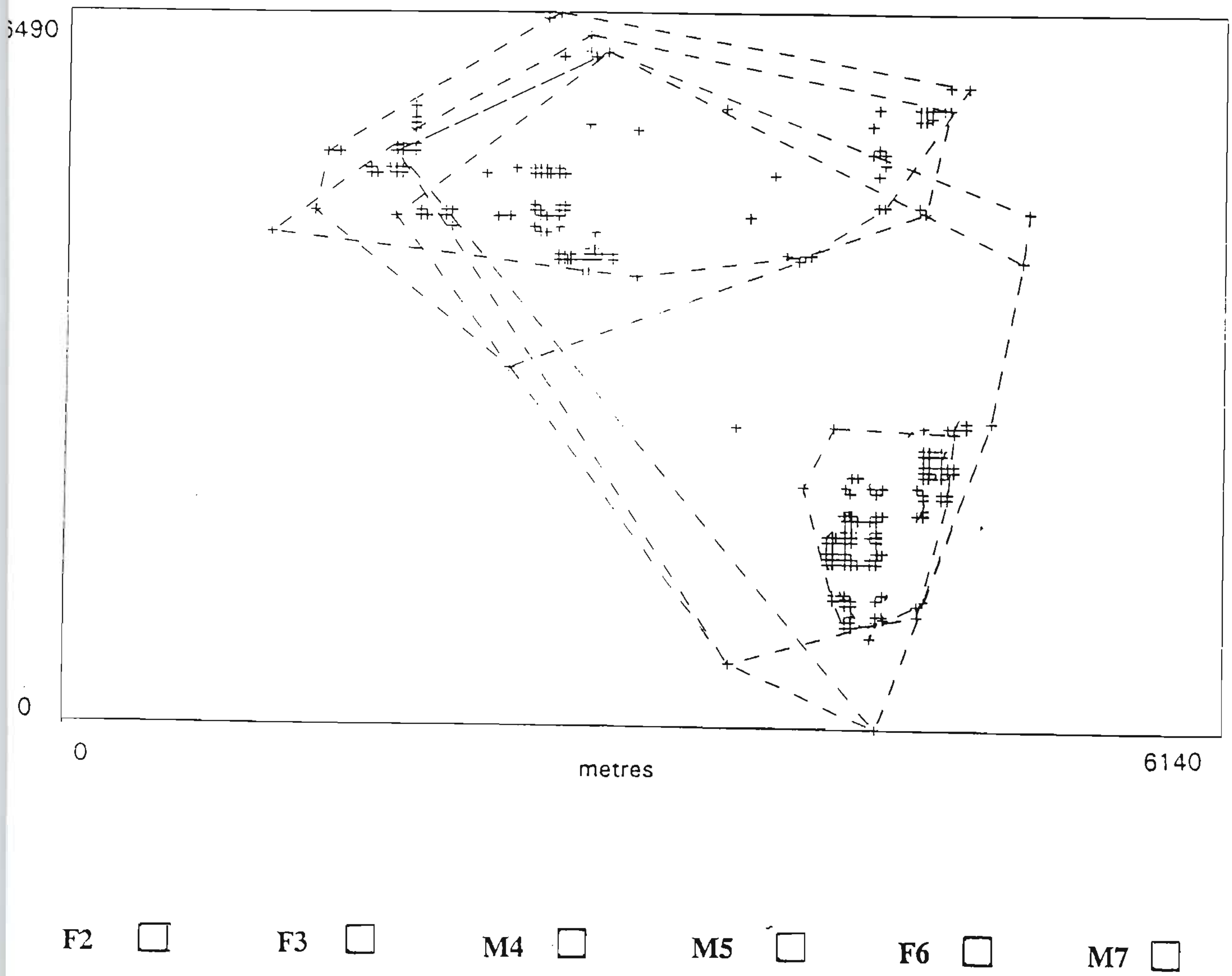
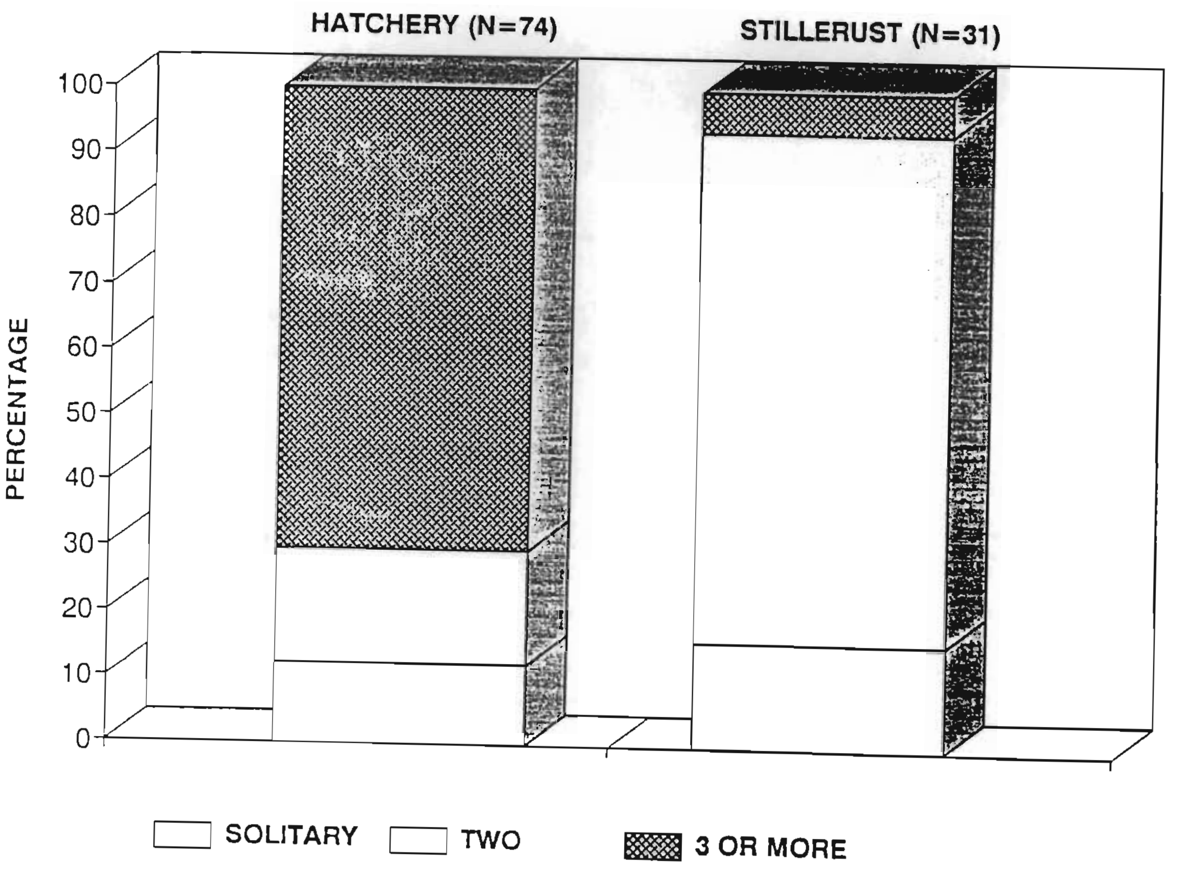


Figure 7.2 Overlapping home ranges of the six radio-tracked spotted-necked otters.

7.3.2.1 GROUP SIZES

Spotted-necked otters were observed mainly in twos or in groups of three or more individuals, and rarely was a single individual observed. Differences in the number of observations in which a single animal, two animals, or a group was observed were significantly different from random (chi-square=23,01; p<0,001).

Table 7.2 Group sizes of spotted-necked otters recorded during the study (N=105).



Differences were detected in the group sizes between the Hatchery and the Stillerust areas (Figure 7.3). At the Hatchery animals were seen mainly in groups (70%), while at Stillerust they were observed mainly in twos (77%). As illustrated in Table 7.3, differences in the number of observations of solitary animals, twos, and larger groups at the Hatchery and in the Stillerust area were significant (Chi-square=39,8; p<0,001).

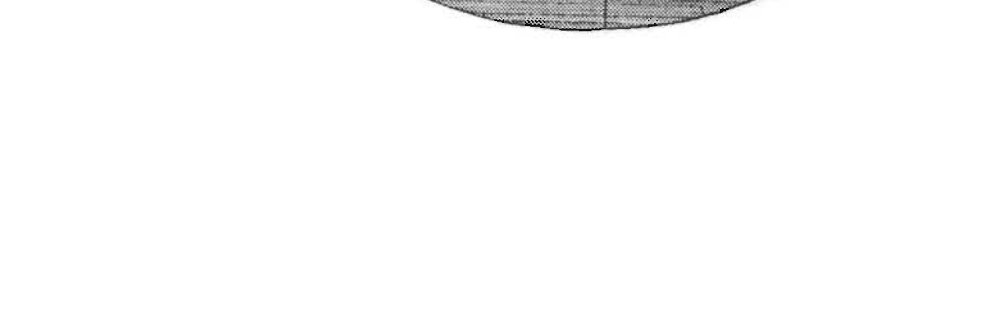


Figure 7.3 Intraspecific relationships: overall analysis.

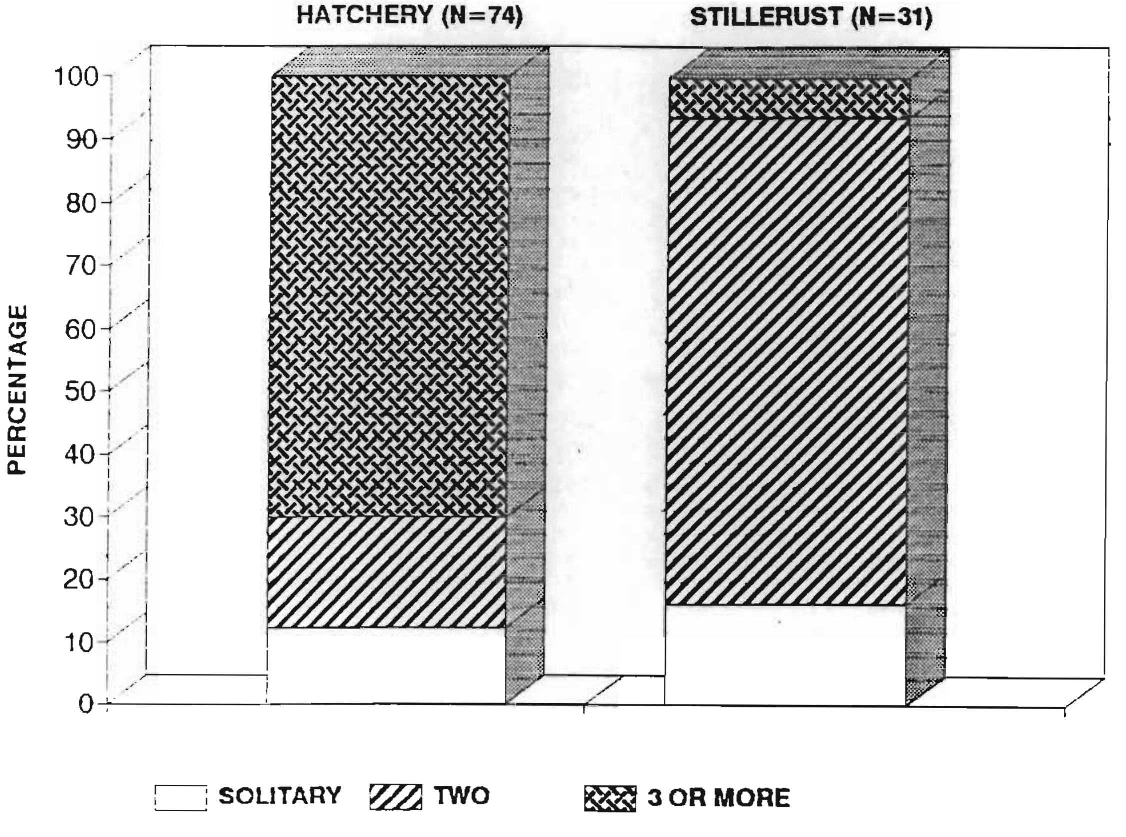


Figure 7.4 Group sizes of spotted-necked otters: comparison between the Hatchery and the Stillerust areas.

These results show that spotted-necked otters have overlapping home ranges both in the Stillerust and in the Hatchery areas, whereas active interaction between individuals with overlapping home ranges, is limited to the Hatchery area.

Table 7.3 Contingency table: comparison between group sizes at the Hatchery and at Stillerust.

GROUP SIZE	HATCHERY observed	HATCHERY *expected*	STILLERUST observed	STILLERUST *expected*	total
1	9	*9,9*	5	*4,1*	14
2	13	*26,1*	24	*10,9*	37
3 +	52	*38,0*	2	*15,9*	54
total					105
chi-square = 39,8 p<0,001					

7.3.2.2. COLE'S COEFFICIENT OF ASSOCIATION

Further information concerning the social behaviour of spotted-necked otters was obtained using Cole's association index. The higher degrees of association were found among M4, M5, and M7, while F2 and F6 strongly avoided each other. Association between F2 and

Table 7.4 Cole's coefficient of association (CA) values.

HATCHERY		STILLERUST	
otters	Cole's coeff.	otters	Cole's coeff.
M4+M5	0,63	F2+F3	0
M4+M7	0,76	F2+F6	0,02
M5+M7	0,79	M4+F2	0,01
M4+F3	0,07	M4+F6	0,02
M5+F3	0,08	M5+F2	0,01
M7+F3	0,09	M5+F6	0
		M7+F2	0,01
		M7+F6	0
mean	0,4		0,01
Student's t Test: t = 12,64 p<0,001			

F3 (considering observationscollected during the first month of radio-tracking, when F3 was in the Stillerust area) was never recorded. Intermediate degrees of association were detected between F3 and the three males M4, M5 and M7. Values of Cole's association index are illustrated in Table 7.4.

Significant differences (Wilcoxon Mann-Whitney U test: $P(U<=a)<0,0001$) were detected by comparing the values of association obtained for the animals moving predominantly in the Hatchery area and the values concerning the animals moving largely in the Stillerust area. As already shown, association among individuals in the Hatchery area, where food resources were abundant and concentrated, was significantly higher than the association among individuals at the Stillerust area, where food resources were dispersed and varied seasonally in abundance.

7.4 DISCUSSION

7.4.1 USE OF SPACE

Estimating home ranges of species whose presence is restricted to specific habitats is difficult, because home range areas include areas that the animal never uses. Stumpf & Mohr (1962) argued that the expression of home range in terms of linear units is justifiable for a number of species, including otters. Home ranges of otters living in riverine habitat is often estimated in linear units (e.g.: Erlinge, 1967; Green, Green & Jeffries, 1984; Hussain & Choudhury, 1994; Melquist & Hornoker, 1983). Length of coastal shore line has often been used to measure the home range of otters living in marine habitats (e.g.: Arden-Clarke, 1986; Kruuk & Hewson, 1978; Watson, 1978) and lacustrine habitats (e.g.: Erlinge, 1968). Spotted-necked otters in Kamberg Nature Reserve were constantly using different aquatic habitats, such as river, dams, or oxbow lakes, and an estimation of home ranges in terms of linear units would have been unsatisfactory. The MCP method of home-range estimation gave a more realistic representation of the spatial areas actually used by the radio-tracked animals. This method estimates an animal's home range based on space points where the animal was actually located, while the harmonic mean method is based on a probabilistic use distribution, increasing the chances of including areas caracterized by habitat that would not be used by that species. This also likely explains why home ranges estimated by the Harmonic Mean method were much larger in area than the ones obtained using the MCP method.

Other information concerning home range sizes of spotted-necked otters is not available. In riverine habitat, based on signs of presence, Rowe-Rowe (1992b) estimated a density of one adult per 6-11 km of river. Kruuk & Goudswaard (1990) (Lake Victoria), and Lejeune & Frank (1990) (Lake Muhazi) estimated a density of 1 individual per 1 km of shoreline and 2 individuals per 1 km of shoreline respectively. The European otter is close to the spotted-necked otter in terms of food habits and size, and there is more information on the use of space by this species. Home range sizes estimated for the European otter are expressed in linear units, and vary from 7 km to

39.1 km of river (Erlinge, 1968; Green, Green & Jeffries, 1984). The lengths of river used by the radio tracked spotted-necked otters (average length: 14.8 km) is within the range of the European otter. Differences in home range area between males and females are commonly found in many species, including otters (e.g.: Dunstone & Birks, 1985; Erlinge, 1968; Erlinge, 1977; Green, Green & Jeffries, 1984; Skirnisson, 1986; Waser & Waser, 1985; Wynne & Sherbune, 1984;). The spatial organization of males is influenced by three resources, food, cover, and receptive females, while in females home range size is determined by food and cover, and adjusted so that food availability is also sufficient when food resources are low (Sandell, 1989). Consequently, males generally have home ranges larger than those of females, because range area in males is a function not only of food requirements but also of the distribution of females. The strong correlation between females home range area and food availability explains the differences in the home range area among the three radio-tracked females. F2 and F6, resident in the Stillerust area, had home ranges similar in area and significantly larger than that of F3, which was resident at the Hatchery. As described previously, the Hatchery area included several dams regularly stocked with trout, and therefore food resources were concentrated and abundant throughout the year; however, in the Stillerust area resources were more dispersed and varied seasonally in abundance.

7.4.2 INTRASPECIFIC RELATIONSHIPS

Radio-tracked animals did not show any intersexual or intrasexual territorial behaviour. Variation in social behaviour in response to resource availability has been found in many species (e.g.: Bekoff, Daniels & Gittleman, 1984; Kruuk, 1978; Kruuk & Macdonald, 1985; Macdonald, 1983; Mills, 1989). With the exception of what has been recorded by Lejeune (1989), who observed 75% solitary animal, in central African lakes otters were observed mainly in groups. At Lake Victoria small groups were mainly seen, but groups up to 10 or 20 occurred (Kruuk & Goudswaard, 1990; Procter, 1963). In South Africa spotted-necked otters have been mainly observed singly or in groups of two or three, occasionally up to five (Rowe-Rowe, 1978). Spotted-necked otters seem therefore to be social, but modify their degree of sociality in response to food resource availability. Central African lakes are highly productive in terms of fish, while South African rivers are relatively poor.

Previous authors have not recorded social interactions between individuals constituting groups. Even if not quantified, social interactions, such as allogrooming, vocalizations and cooperation in hunting, were frequently observed during this project between the individuals at the Hatchery.

A strong influence of food resource abundance and dispersion on the social behaviour of spotted necked otters can be hypothesized based on the following results:

- At the Hatchery animals were observed mainly in groups of three or more individuals (average 3-5), while at Stillerust animals were observed mainly in twos

- Home ranges of radio-tracked spotted-necked otters overlapped both at the Hatchery and at Stillerust, but animals interacted more significantly at the Hatchery

According to the foraging theory developed by Charnov (1976), Krebs & McCleery (1978), and Pyke (1984), when a predator is hunting in a certain patch, prey availability decreases in that patch with time because of the disturbance caused by the presence of the predator. If more predators hunt at the same time in the same patch, the disturbance effect is amplified, and consequently the hunting success is lower than if a single individual is hunting in that patch. At the Hatchery food was not a limiting resource, and consisted of natural prey plus a constant supply of trout in the dams. At Stillerust spotted-necked otters were living solely on natural resources, subject to seasonal changes in abundance. Hunting at the same time in the same patch was therefore much less efficient in the latter area.

CHAPTER 8 CONCLUSIONS

Kamberg Nature Reserve was an ideal area to study the ecology of spotted-necked otters. Including a trout hatchery with stocked dams, a rural village, farmland, and a natural area, it was possible to compare the otter's ecology in different environments and to identify factors determining or affecting its presence. Habitat-use analyses confirmed that spotted-necked otters are strictly linked to aquatic environments.

Both in habitat use and in spacing patterns spotted-necked otters show a certain degree of adaptability. Group sizes were strongly influenced by food resource abundance and availability; otters occured in larger groups where food was consistently available throughout the year, while animals tended to be more solitary and less interactive where food availability was natural and seasonally variable in abundance, even if tolerance among conspecifics was mantained. Spotted-necked otters used dams constantly, although they are man-made habitats, in order to exploit an alien or introduced food resource (trout). Literature concerning the diet of spotted-necked otters confirms the adaptability of the species. Spotted-necked otters are mainly piscivorous, but in environments in which fish are scarce, other items (crabs and frogs) become part of the diet.

Although adaptable to different environmental situations, certain factors determining the spotted-necked otter's presence were identified; these were bank cover and human disturbance. Both at the Hatchery and at Stillerust, animals preferred high vegetation cover along the banks. The stretch of river flowing through the farmland (Tendele Village and Riverside) was used only when travelling between the two protected areas mentioned above. River banks in the farmland were poorly covered, since pasture and cultivation extended right to the river banks, and human disturbance, including active persecution of otters, was constant, especially in the stretch of river flowing through the rural village.

The following factors should therefore be considered as determining the presence of spotted necked otters:

- vegetation cover on river banks
- water quality (on which food resources are dependent)
- human disturbance, especially where human presence implies environmental deterioration or, obviously, persecution of the species. Controlled human presence, such as ecotourism at the Hatchery, did not seem to disturb the radio-tracked animals.

Since spotted-necked otters are not territorial, the minimum area needed in order to mantain a viable population is strictly dependent on food resource availability. The present study showed how home range size and social behaviour, and consequently density of the species, is dependent on the environment's carrying capacity. Further research is needed to determine the effects of habitat fragmentation on spotted-necked otter movements. In the present study, the 11 km of river flowing through the farmland did not constitute an obstacle to otter movement or in exchanges between the Hatchery and the Stillerust animals.

In order to draw up a conservation plan for spotted-necked otters in the Natal Drakensberg further research should be conducted, focusing on the following aspects:

- Mapping habitat suitable for the spotted-necked otter
- Determining the effects of habitat fragmentation on spotted-necked otter movements and maximum tolerable distance among suitable areas
- Determining the genetic status of the spotted-necked otter population.

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APPENDIX 1

BONFERRONI CONFIDENCE INTERVALS (p<0,01)

Table 1 Selection of protected and unprotected areas.

	INTERVALS OF CONFIDENCE	selection
PROTECTED AREAS	0,934127<=p=<0,958870	+
UNPROTECTED AREAS	0,041129<=p=<0,065872	-

Table 2 Overall habitat selection while resting.

	INTERVALS OF CONFIDENCE	SEL.
TREE	0,255570<=p=<0,325540	+
REED	0,174210<=p=<0,236467	+
GRASS	0,113865<=p=<0,167448	-
ROCKS	0,010367<=p=<0,032753	+
SWAMP	0,085758<=p=<0,133954	0
ISLE	0,199503<=p=<0,264562	+

Table 3 Seasonal habitat selection while resting.

WET SEASON			DRY SEASON		
	INTERVALS OF CONFIDENCE	SEL.		INTERVALS OF CONFIDENCE	SEL.
TREE	0,270257<=p=<0,376933	+	TREE	0,218521<=p=<0,310778	+
REED	0,938199<=p=<0,291573	+	REED	0,132559<=p=<0,211485	+
GRASS	0,181292<=p=<0,277134	-	GRASS	0,040171<=p=<0,092153	-
ROCKS	0,001544<=p=<0,029916	0	ROCKS	0,009680<=p=<0,043249	+
SWAMP	0,017988<=p=<0,062910	-	SWAMP	0,129126<=p=<0,207357	+
ISLE	0,107794<=p=<0,188834	+	ISLE	0,254428<=p=<0,350486	+

CONTINGENCY TABLES

Table 4 Comparison between habitat use while resting at the Hatchery or in Stillerust area.

	HATCHERY observed	HATCHERY *expected*	STILLERUST observed	STILLERUST *expected*	TOT
TREE	223	*197,92*	54	*79,11*	277
REED	154	*122,90*	18	*49,11*	172
GRASS	11	*118,64*	155	*47,43*	166
ROCKS	16	*15,01*	5	*5,90*	21
SWAMP	51	*69,33*	46	*27,74*	97
ISLE	241	*172,20*	0	*68,81*	241
TOT	696		278		974

Chi-square= 493,38 p<0,001

Table 5 Comparison between habitat use while resting during the wet and dry seasons.

	WET SEASON observed	WET SEASON *expected*	DRY SEASON observed	DRY SEASON *expected*	TOT
TREE	144	*129,70*	140	*154,24*	284
REED	108	*90,92*	91	*108,19*	199
GRASS	102	*62,61*	35	*74,47*	137
ROCKS	7	*9,59*	14	*11,41*	21
SWAMP	18	*48,88*	89	*58,11*	107
ISLE	66	*103,27*	160	*122,76*	226
TOT	445		529		974

Chi-square= 116,35 p<0,001

APPENDIX 2

CONTINGENCY TABLES

Table 1 Comparison between the percentages of activity and resting during 24h periods in the Hatchery and Stillerust areas.

	HATCHERY observed	*expected*	STILLERUST observed	*expected*	TOT
ACT	506	*505,18*	200	*200,84*	706
REST	696	*696,83*	278	*277,15*	974
TOT	1202		478		1680

Chi-square=0,007

Table 2 Comparison between the percentages of activity and resting during 24h periods of males and females.

	MALES observed	*expected*	FEMALES observed	*expected*	TOT
ACT	395	*397,41*	294	*291,60*	689
REST	574	*571,65*	417	*419,49*	991
TOT	969		711		1680

Chi-square=0,057

Table 3 Comparison between the percentages of activity and resting during 24h periods during the wet and the dry seasons.

	WET SEASON observed	*expected*	DRY SEASON observed	*expected*	TOT
ACT	330	*325,79*	376	*380,30*	706
REST	445	*449,33*	529	*524,67*	974
TOT	775		905		1680

Chi-square=0,186

Table 4 Comparison between the activity rhythms during 24h periods in the Hatchery and Stillerust areas.

	HATCHERY observed	*expected*	STILLERUST observed	*expected*	TOT
0-3	24	*22,91*	8	*9,11*	32
3-6	51	*43,74*	10	*17,21*	61
6-9	94	*93,27*	36	*36,84*	130
9-12	51	*50,20*	19	*19,83*	70
12-15	34	*38,76*	20	*15,39*	54
15-18	85	*92,44*	44	*36,52*	129
18-21	110	*100,38*	30	*39,72*	140
21-24	65	*55,96*	13	*22,10*	78
TOT	506		200		706
Chi-square=17,11					

Table 5 Comparison between the activity rhythms during 24h periods of males and females.

	MALES observed	*expected*	FEMALES observed	*expected*	TOT
0-3	23	*17.4*	7	*12.6*	30
3-6	37	*37.8*	23	*25.2*	60
6-9	80	*79.4*	57	*57.6*	137
9-12	43	*42.9*	31	*31.1*	74
12-15	19	*31.3*	35	*22.7*	54
15-18	77	*78.2*	58	*56.8*	135
18-21	84	*78.8*	52	*57.2*	136
21-24	45	*45.2*	33	*32.8*	78
TOT	408		296		704
Chi-square=16,82					

Table 6 Influence of the moon on nocturnal activity of the spotted-necked otters.

	MOON PRESENT observed	*expected*	MOON ABSENT observed	*expected*	TOT
active	89	*72,8*	78	*94,2*	167
resting	129	*145,2*	204	*187,8*	333
TOT	408		296		500

Chi-square=9,61 p<0,01

Table 7 Comparison between the activity rhythms during 24h periods during the wet and the dry seasons.

	WET SEASON observed	*expected*	DRY SEASON observed	*expected*	TOT
0-3	7	*14.01*	23	*15,94*	30
3-6	46	*29,05*	16	*33,09*	62
6-9	65	*63,52*	71	*72,56*	136
9-12	36	*34,65*	38	*39,44*	74
12-15	30	*24,88*	23	*28,29*	53
15-18	53	*63,11*	82	*71,93*	135
18-21	64	*63,14*	71	*71,92*	135
21-24	39	*36,07*	38	*41,02*	77
TOT	330		376		706

Chi-square=31,01 p<0,001